THE

THEORY

OF

FIELD-FORTIFICATION.

BY

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INTRODUCTION.

I HAVE called this Work *the Theory of Field-Fortification*, as my plan was not only to lay down proper rules for constructing and disposing field-works, but also to explain the principles upon which those rules are founded; and, indeed, an officer can only attain a very superficial information when, in the course of his studies, he is reduced to the necessity of taking for granted what is said by an author, as the propriety of the methods which he recommends is not demonstrated. Demonstrations not only convey to the mind of a reader a knowledge of the principles upon which some proposed methods are founded, but they unfold his ideas, gradually improve his notions of the subject, and enable him, in all cases, to apply, with facility, the rules which he has learned, as a certain practice, united with his

theoretical information, will suffice to guide him, if he possess *coup-d'œil.*

I shall here advert to a very erroneous opinion which, unfortunately, prevails amongst some military characters; namely, that an officer who does not belong to the corps of Engineers wants no further knowledge of field-fortification than the practical part of it which relates to the construction of the works that he may have occasion to construct. It is not indispensably required, I own, that an officer of the line should be acquainted with the details of that branch of science as well as an engineer; but he ought to know, at least in a general way, its application to all military operations; and also the effect which works may produce, according to their nature, construction, and disposition; for instance, although intrenchments of armies, lines of frontiers, grand têtes de pont, &c. are generally constructed by engineers, yet they are connected with military operations in the department of officers of the line, who, besides, may be ordered to reconnoitre, attack, or defend them; and how could they do so, with credit to themselves, and with

advantage to their country, should their knowledge of field-fortification be confined within the narrow bounds improperly affixed to it?

Not to divert uselessly the attention of most of my readers from the subjects of which I have treated in this work, the methods of performing such common practical operations as are generally known, have been omitted; some young officers, however, may not be sufficiently acquainted with them, and as it is my wish not to pass over any details which may be useful to the army in general, I shall explain those common operations in a Supplement to this work, which will very shortly appear, under the title of *Practical Field-Fortification*.—Such definitions will also be given in the Supplement as may be requisite for the undoubtedly very small number of young officers who are entirely unacquainted with geometry and fortification in general; and it is proper that they should peruse those definitions before they read either *the Theory of Field-Fortification* or the Supplement, &c.

No scales have been introduced in this work, as I am convinced that a scale which

is not sufficiently large to be accurately divided, and to allow every part of a work constructed after it to be represented with its proper dimensions, is dangerous rather than useful; since it cannot be of service to any reader, and may mislead many; but I have annexed the dimensions to the figures, whenever I thought it requisite for greater perspicuity in the explanations.

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THE THEORY

OF

FIELD-FORTIFICATION.

PART THE FIRST.

Difference between PERMANENT *and* TEMPORARY, *or* FIELD-FORTIFICATION; *Maxims or General Rules to be observed in the tracing of* FIELD-WORKS; *of* REDANS *or* FLECHES *and* PIECES; *of* REDOUBTS; *a Critique on the Methods recommended by* STRUENSEE, CESSAC LACUEE, TIELKE, *and others, for calculating the necessary Extent of* A REDOUBT, *according to its Garrison and Artillery; a new Method proposed; the Use of the* PLAIN TABLE *for taking the Plan of a Work, and for tracing it on the Ground; Description and Use of the* DECLINATOIRE; *Observations on* REDOUBTS EN CREMAILLERE; *of* STAR-FORTS, FORTS WITH DEMI-BASTIONS, FORTS WITH BASTIONS, TETES DE PONT, *and* INTRENCHMENTS OF ARMIES.

CHAPTER I.

1. TEMPORARY or *field-fortification*, like *permanent fortification*, has for its object to enable a body of men to resist with advantage the attack of a greater force; and indeed, these two branches of science are grounded on the same principles, but modified by the difference of the means that may

be employed for constructing, attacking, or defending *permanent* and *field works*.

In constructing a *fortress*, our intention is to cover a point which, considering the importance of its situation on our frontiers, it is material to secure at all times: of course, the works thrown up ought to have a degree of durability suitable to the purpose intended; these works are constructed long before hand, most generally in time of peace, and with abundance of means of all kinds; they are combined and disposed in such a manner as to require a regular attack, supported by cannon, in which the besiegers can only proceed by degrees; the fronts of attack, besides, are most frequently determined by the ground itself, as also by the nature and disposition of the works with regard to each other, &c.

But *field-works* are thrown up, merely for a short time; often in haste, without either choice or preparation of the materials employed; with very few means at hand, and sometimes in presence, as it were, of the enemy; besides, there are many cases in which they are not intended to resist an attack supported by cannon, and when they are, the nature of the guns which will probably be brought against them, may be different according to the importance of the works. Lastly, field-works are usually attacked by troops formed into columns; which, advancing rapidly in the direction of their

capitals, threaten many points at once; therefore, the dispositions for their defence ought to be different from those for permanent works, &c.

Having thus pointed out briefly the principal differences between permanent and field fortification, I now proceed to explain the maxims or general rules that are to be observed in the latter.

CHAPTER II.

MAXIMS OR GENERAL RULES TO BE OBSERVED IN FIELD-FORTIFICATION.

1.

2. IN general, a saliant angle should not be less than 60°, especially when it is undefended by any flank fire.*

* Experience teaches us, that a soldier in general fires straight before him without taking aim, and in a direction perpendicular to the crest of the parapet behind which he stands; now if we examine the saliant angle *b a c*, pl. 1. fig. 3. we shall see that the *lines of fire*, *a d*, *a e*, being perpendicular to its sides *a b*, *a c*, there

2.

The *saliants** being the most exposed points, particularly when they are not flanked,† their defence ought to be carefully attended to; when the ground and intended object of the work you construct will allow you to direct the saliants towards some natural obstacles which prevent the enemy approaching them on the prolongation of the capitals, you ought to avail yourself of that advantage; but if you cannot direct the saliants thus, they must be protected, if possible, by some artificial obstacles.

is in front of it a sector of a circle *f a g*, which is only defended by the single direct shot *a h*, and increases in the same proportion as the angle *b a c* becomes more acute; even supposing that angle to be 90°, and the thickness of the parapet only eight or nine feet, a column of 18 or 20 men in front could approach it, on the prolongation of the capital, without having any other direct fire to fear than that single shot *a h*. Besides, the less open the angle *b a c* is, the less space it contains; and the easier it is for the enemy to enfilade its sides, since he can take their prolongations with greater facility.

* The particular name *saliants* is given both to the vertex of such angles of field-works as are the most projecting towards the enemy, and to the angles themselves.

† The reason is, that the saliants are the nearest points to the enemy, who in general approach them by following in their march the prolongation of their capitals. I have also shewn, that when saliants are not flanked, there is in front of them an undefended sector of a circle which secures the assailants in their approach.

3.

In tracing field-works, let there be as many flank defences as possible.*

4.

When one part of a fortification is to flank another, it must be so disposed as to make with it an angle not less than 90°, and exceeding as little as possible 90°; in order that the ditch and counterscarp of the part flanked may be defended by a direct fire from that which flanks it.†

* I have already said, that field-works are in general attacked briskly, and by troops in columns, which, besides presenting a small front, advance in the direction of the capitals, where they have very little to fear from the defence in front; the flank-defences, therefore, are the most essential, and there ought to be as many of them as possible.

† It has been explained, that a soldier fires in general straight before him, without taking aim, and in a direction perpendicular to the crest of the parapet behind which he stands; thus, if *b c*, pl. 1. fig. 1. is intended to flank *a b*, and the angle *a b c* be acute, it is clear that the troops will fire upon each other, as shewn by the lines of fire *d e* and *f g*.

If, on the contrary, the angle *a b c* is obtuse, as in fig. 2, the fire from *b c* will pass at a distance from the counterscarp of *a b*, as is shewn by the line of fire *d e*, especially towards the saliant *a*, and this distance will increase in proportion as the angle *a b c* is more open; so that not only the ditch and counterscarp near the saliant *a*, which is the usual point of attack, will remain undefended by any direct fire, but also the ground *f g* in front of it.

But, when the angle formed by the flanked part *a b*, and the flank *b h*, is right, or nearly so, as *a b h* in the same fig. 2. then both

the ditch and counterscarp of *a b*, and also every part of the ground in front of the saliant *a*, are defended by a direct fire from *b h*, as is shewn by the dotted line of fire *i k*; so that the assailants cannot approach the work without being exposed to its effect.

The propriety of having the ditch and counterscarp defended by a direct fire from the flanking parts, is contested by Bousmard (vide *Essai Général de Fortification, par Bousmard*, page 256, vol. 3.) and several other engineers, who support their opinion by saying, that as field-works have in general a small relief,* and narrow ditches of course, it cannot be expected to defend the latter effectually by a direct fire from the flanks; their reason most likely is, that owing to the narrowness of the ditches, the direct fire from the flanks, which may be applied to their particular defence is inconsiderable, so that they cannot be powerfully protected by it, which I readily acknowledge. Bousmard, therefore, and such engineers as are of his opinion, recommend the angle *a b c*, pl. 1. fig. 2. which the flank *b c* makes with the flanked part *a b*, to be obtuse, instead of being a right angle, such as *a b h* in the same figure; the effect of the former construction is, that the ditches and counterscarp are still less defended than in the latter, as I have demonstrated, but it gives the unquestionable advantage of having the assailants sooner exposed to the direct fire of *b c*, since they will be exposed to it at *l*, when the angle *a b c* is 100°, and only at *m*, should it become a right angle such as *a b h*; thus, it is necessary to examine, 1st, Whether that advantage extends as far as Bousmard and his supporters imagine? 2d, Whether it is not overbalanced by inconveniences arising from it? I shall observe, first, that the distance from the flank *b c* to the prolongation of the capital *n p*, in the direction of which the attacking columns generally advance, and the extent of the undefended space *f g* in front of the saliant *a*, increase in the same proportion as the angle *a b c* becomes more obtuse; therefore, the obliquity of that angle, on which depends the dis-

* *By the word* relief *is meant the vertical distance from the bottom of the ditch to the crest of the parapet.*

tance *l m*, ought not to be carried far, especially when *a b* is of a certain length; otherwise, the musketry fire from *b c* could not properly oppose the approach of the columns; these, of course, as they move very rapidly, will not require a long time to go over the distance *l m*, and I will venture to say, that the additional loss which they must sustain from their being sooner exposed to the fire of *b c*, would never be so great as to create amongst them any considerable confusion, and more effectually prevent their advancing; indeed Bousmard says, that some *artificial obstacles* should be disposed in the ditch and thrown up in the way of the columns, to obstruct and slacken their march; but he himself owns, page 257, that there is not always a sufficient time for preparing those obstacles, which require besides a supply of proper materials that in many circumstances you will not be able to procure; now, let us suppose that none has been thrown up, and that the ditch and counterscarp, as also the ground *f g* in front of the saliant, can be defended only by an oblique fire from *b c*, as will be the case, if the angle *a b c* is obtuse; then the assailants, after approaching the work, will enter the ditch with very little danger to themselves, spread all along in almost perfect safety, form in good order with scarcely any annoyance, and prepare for escalading the parapet at all points, in order to attack the defenders in front, in flank, and even in reverse.

Let us suppose now that obstacles have been thrown up in the way of the columns, and others in the ditch: with regard to the former, I shall observe that they ought not to be placed at any considerable distance from the work, the fire of which could not then properly support them; therefore, the advantage they give of keeping off the enemy, will not extend much farther when the angle *a b c* is obtuse than when it is a right angle, as *a b h*; as for the obstacles in the ditch, it will certainly be much easier to the assailants to overcome them in the former case than in the latter: 1st, because the space *f g*, which, as has

5.

The length of the lines of defence ought not to exceed 80 toises at most.*

been explained, can be defended only by an oblique fire from *b c*, the angle *a b c* being obtuse, will enable them to prepare with greater safety for the destruction of those obstacles; 2dly, because the ditch being nearly destitute of every actual defence, they will remove them with much greater facility than they possibly could, should they be exposed to the annoying, although not very powerful, direct fire of *b h*; besides, it is evident that either on account of the smoke, or by the negligence and precipitation of the soldiers in taking aim, and in foggy weather, the troops which man the parapet may be exposed to their own fire, when it is oblique and the enemy close to the work. Lastly, if an oblique defence may prove effective, why could not the soldiers, placed along the parapet, *b h*, fire obliquely upon the enemy, before he is exposed to their direct fire?

I have hitherto supposed that there is no artillery: should there be any, it might in some cases occasion differences; but these are exceptions to the general rule, and as field-works receive in general their principal defence from the fire of small arms, every thing which relates to that defence ought to be calculated accordingly; therefore, far from coinciding in opinion in this important question with Bousmard and his supporters, I still persist in my own, namely, that in field-fortification the angle formed by the flank and the flanked part, ought to exceed 90° as little as possible.

* In permanent fortification, the extent of the lines of defence is allowed to be from 125 toises to 130, I mean for the body of the place, as it may be defended with *wall-pieces, rifled guns, hook-arquebuses*, &c. which are kept on purpose in the arsenals of fortresses, and have a range of 150 toises, or thereabout; but in

6.

Avoid the second flank defence, unless you are obliged to have recourse to it.*

7.

Be careful not to suffer any cover in the vicinity of a work, under which the assailants may approach unperceived.

8.

Dead angles are to be avoided as much as possible.†

9.

A fortification must alawys be proportioned to the number of men who are to defend it; and the length of the parapet remaining the same, you ought to enclose within it the greatest possible surface.‡

field-fortification, where common muskets are used, the range of which is no more than about 100 toises, the lines of defence ought not to exceed 80 toises, that the fire from the flanking parts may cross sufficiently in front of the saliants, and be effective.

* This maxim is a consequence of maxim 4.

† Indeed, dead angles, when re-entering, are less dangerous in field than in permanent fortification, as you have no breach to fear in the former; it is proper, however, to avoid them as much as you can.

‡ Should a fortification be too extensive, for the number of men who are to defend it, its defence would be weak; on

10.

Before you begin a work, you ought to ascertain whether you have sufficient means for completing it in time.*

CHAPTER III.

OF THE PRINCIPAL OR OUT-LINE OF FIELD-WORKS.

OF REDANS OR FLECHES.

3. As *redans* or *flêches*, pl. 1. fig. 3, can be quickly and easily constructed, they are frequently used in the field, where, as I have observed, No. 1, you are often obliged to work in haste, with few means at hand, and deprived of the

the contrary, if it has too little extent, the troops could not be at ease, nor execute their movements without confusion.

* Without that precaution you would often run the risk of beginning a work you could not finish, and from which consequently you would derive no advantage.

possibility of throwing up in time works capable of great resistance; besides, in many circumstances the intended object of a work does not require that it should be able to afford an obstinate defence; very weak indeed is that which a redan can make, particularly when isolated; for then, independent of being easily carried in front, owing to the undefended sector *f a g*, its gorge *b c* is also greatly exposed, and you ought not to rely on the defence of a redan, unless it is supported in its rear; such are, for instance, redans thrown up in front of an army you intend to intrench, and on the banks of a river to cover a bridge, or defend a ford: or those you construct on a dam, in a morass, an inundation, and in the avenues of a village defended by troops, &c. the gorges of which are consequently secure.

Sometimes also redans are placed in front of a main work, either to cover its communications with the country, or to defend some parts of the ground which cannot be seen from it, and would be of advantage to the enemy in directing their attacks: or in short to procure a cross fire on the capitals of the main work, and keep the enemy at a distance from it. Redans so disposed are called *Lunettes.**

* Redans are also sometimes used for covering the grand guards of an army and advanced posts; *a gate, a barriere,* the avenues of a castle, country-house, &c.

No fixed rules can be given with regard to the length and direction of the faces of a redan,* since both vary according to the ground, the intended object of the work, and the strength of the detachment that it is to cover, &c. As for its tracing, which, as the figure shews, consists in nothing more than describing an angle on the ground, it is so simple as not to require much explanation, and I will only say, that after having fixed upon the point where, in your opinion, the vertex *a* of the angle formed by the redan can be placed to the greatest advantage, according to the ground and intended object of the work, you ought to regulate the direction of the faces *a b*, *a c*, in the manner most suitable to your purpose, and their length proportionably to the strength of your detachment, as I shall explain more minutely hereafter.

With respect to the dimensions relative to the thickness and height of the parapet of a redan, to its ditch, &c. they will be found in the 2d part of this work, where I shall enter into the neces-

* Sometimes, and in order to discover some parts of the ground which cannot be seen from the faces *a b*, *a c*, of a redan, pl. 1. fig. 4, flanks are given to it, such as *b d*, *c e*, in which case the redan assumes the name of *piece*; no fixed rules can be laid down with regard to the length and direction of those flanks, any more than for the faces of the redan, since both entirely depend on the disposition of the ground and extent of the redan itself.

sary details concerning the profile of field-works in general.

OF REDOUBTS.

4. Redoubts, as well as redans, are frequently used in the field; where, as isolated works, they are employed, when the post or detachment to be entrenched being abandoned to its own strength, and without any protection in its rear that may prevent its being turned, it becomes necessary to enclose it entirely, so as to secure it from the attacks which the enemy may make upon it on all sides. Redoubts are extremely proper for covering an advanced post, a grand guard, or a communication; for defending a defile, a height; for protecting a retreat, the passage of a river, ford or bridge; for supporting the wings of an army, a line of frontiers, &c.; independent of being easily constructed, they have also the advantage of affording a very good defence when supported from without, and even of being sometimes effectually used instead of *fortins* or *field-forts*, which in general require more time and materials for their construction, and a more numerous garrison for their defence.

5. Redoubts, however, when they are not flanked by some other fire, have two essential defects; the

first is, that their saliants are unprotected,* which cannot be remedied but by adapting to those saliants a few teeth of cremaillère, *a b c*, &c. pl. 4. fig. 18, of which I shall speak hereafter, or, when the ground and every other circumstance will allow it, by directing the saliants, conformably to Maxim II. towards some inaccessible points; and lastly by placing in front of them, when possible, some artificial obstacles, such as *abatis*, *trous de loup*, &c.† Indeed, circular redoubts, pl. 2. fig. 9.

* I beg the reader will remember what I have said in the note belonging to Maxim I. and if he examines the redoubt represented by fig. 5. pl. 1. he will see that, (as well as in the redan, fig. 3. of the same plate,) there is in front of each saliant a sector, *b a c*, which is not defended by any other fire than the single direct shot, *a d*.

† Two other methods have also been proposed for remedying this defect: the first is to trace the parapet in a straight line *d e*, opposite the saliant, as in pl. 2. fig. 6; in the second method, the parapet opposite the saliant is made circular, as in fig. 7. I shall observe, with regard to the first method, 1st, that the number of lines of fire, *d f*, *c g*, &c. which it procures along the capital must be inconsiderable; for if, in order to augment them, much length was given to the line *d e*, the parapet would acquire at the saliant a considerable thickness, and difficulties would occur relative to its superior slope; the interior space of the redoubt would also be greatly reduced: the second and chief consideration is that no advantage results from defending the saliants of a redoubt by this method: for it procures two new sectors, *h d i*, *m e n*, which

have not that defect, as their fire, which has no fixed direction, may incessantly vary and spread itself on every point of the ground that surrounds them. They have, besides, this advantage over the square and polygonal redoubts; namely, they inclose a greater surface, the length of the parapet being the same; but they have the inconvenience of being more difficult to construct, and not suiting all kinds of ground, as the defence which they present is uniform on every point of their circumference, whereas, on the contrary, it is most frequently your object in constructing a redoubt to direct more fire upon certain fixed points than upon any other.*

are only defended by the single direct shots, *d o*, *e p*, for which reason two columns may advance without danger, by marching in a direction parallel to that of the capital, and leaving betwixt them the space *f d e g*, which is defended by the fire from the line *d e*.

The second method is preferable; for it does not increase so much the thickness of the parapet at the saliant as the other method does, and diminishes less the interior space of the redoubt; besides, the whole of the ground, *f g*, in front of the saliant is defended by shots, not very numerous I own, but still annoying to the enemy, who cannot avoid them, as, owing to the circular form of the parapet *d e*, those shots have no fixed direction, and may continually oppose the assailants.

* It may be imagined, that a redoubt of many sides, pl. 2. fig. 8. procures the advantage of a circular redoubt, without being subject to its defects; such opinion, however, is not well

The second defect of redoubts which are not flanked is, that their ditch is not seen from any part of them; and this defect, which it is impossible entirely to remove, can only be diminished by multiplying, when possible, and disposing in the most advantageous manner, artificial obstacles inside of the ditch, as I shall explain hereafter.* But you will not always be able to avail yourself of that assistance; for the most effectual of those artificial obstacles require time and labour for their construction, and a supply of such materials as perhaps cannot be procured.

After these preliminary observations concerning redoubts, I shall lay down rules to be observed in tracing them; but in order to be more clear, it is proper that I should first determine the length of

founded; first, because the construction of a redoubt of that kind does not present fewer difficulties than the construction of a circular redoubt; besides, the undefended sectors, *b a c*, in front of the saliants, are not so considerable, indeed, as in a square redoubt, or in a redoubt of 5 or 6 sides, but they are more numerous, and afford to the assailants a greater number of accessible points. In general, you must avoid as much as possible constructing any redoubt of more than 4 or 5 sides, especially when the saliants cannot be protected, without neglecting, however, to conform to the ground, and to allow the work a sufficient interior surface for the convenience of the service.

* This observation is not peculiar to redoubts, and may be applied to all works which are not flanked, such as redans, &c.

parapet which in field-works each man must occupy.

6. This important question has been often agitated, and remains still unsettled: some allow two feet of parapet for each man in front, and ground their opinion on this reason, that, when manœuvring, the soldier occupies no more than two feet in the ranks; others find that allowance too little, and give four feet; finally, many assert that the parapet will be sufficiently manned at the rate of two men in front per toise; amongst such various opinions the best way is, to be guided by experience, which appears in favour of the latter; for it is obvious that a soldier placed behind a parapet, which impedes his motions, wants more room for using his arms, and taking aim, than in the ranks; two feet of course are not sufficient for him; on the other hand, experience proves that he can act with ease when he is allowed three feet; therefore, there is no plausible reason for allowing four feet, which would diminish by one-fourth the quantity of fire, and weaken the defence; I shall adopt the proportion of two men per toise.

7. I shall now observe, that the requisite length of the sides of a redoubt depends, not only on the extent which the parapet must have in order that the garrison may man it properly, but on the necessary interior space for containing the men; it should also be considered, whether the troops are

to reside in the work, or to remain there for a short time; as it happens, for instance, when a work is sufficiently near a main body of troops to communicate easily with them, and receive reinforcements, should an attack be expected; in this case, it will suffice to regulate the size of the redoubt in such a manner that the number of men intended for its defence can man the parapet properly, without being crowded and obstructed in their motions; but if the garrison is to reside in the work, its interior surface must be larger.

8. Various methods have been proposed for calculating the necessary length of the interior sides of a redoubt,* according to the strength of its garrison; but most have the double defect of not being applicable to small detachments, as the redoubts would then be considerably too little, and to increase beyond measure the interior surfaces of those works, when their garrison exceeds a certain number of men. To prove this, I shall examine such methods as are more generally known through their authors.

9. Struensee,† for instance, allows as many feet in length to the interior contour of the parapet of a redoubt, as there are men in the detachment, the

* By the interior sides of a redoubt, I mean the interior sides of its parapet.

† A German author who has written a complete course of fortification.

troops being formed two deep, and 10 feet over for each piece of cannon, which he supposes to be light field pieces: when the artillery is composed of larger guns, he allows 14 or 16 feet for each piece.* (Vide the First Principles of Field-Fortification, by Struensee, translated into English by Captain Nicolay, of the Royal Engineers, page 64, § 70, and page 114, § 128.) But this method is not applicable, in general, either to small or to large redoubts: first, it cannot be applied to the former; for let us suppose you have to construct a square redoubt, *a b c d*, pl. 3, fig. 10, for 60 men, and one light field-piece, according to Struensee's rule, you should give 70 feet in length to the interior contour *e f g h* of the parapet, that is 17 feet 6 inches to each interior side *e f*, *f g*, &c. Now let me ask any experienced officer, whether a detachment of 60 men and 1 piece of cannon can be placed in such a work? there will be hardly room for the banquettes and their slopes, and Struensee's method is scarcely worth criticism.† But let us

* This method of calculating the necessary length of the parapet, by reckoning so many feet in length per man and piece of cannon, may be applicable to a line of intrenchments, because you have at your disposal all the ground behind, but it cannot be applied to inclosed works.

† A redoubt, whose interior sides have each 6 toises in length, is the smallest which should be constructed: first, because grenades and shells would do considerable mischief in a smaller re

proceed further: in page 114, § 129, this author directs that "when the garrison of a redoubt is not "only to defend it, but likewise to dwell within "it, as soon as the sides are found, it is also ne- "cessary to compute its area, which will deter- "mine whether there is sufficient space within "the redoubt to afford proper lodging for the sol- "diers." He observes also that "every soldier "requires at least a space of 18 square feet, and a "a gun with its appurtenances 216 square feet." And lastly, he draws this conclusion, page 115, § 130, "that when troops are to be formed two "deep, and the length of the sides of the work is "determined according to the preceding rules, "the interior space will never be large enough to "lodge the men, unless the garrison consists of "at least 200: but when there are more than that "number, it is always sufficiently capacious for "the accommodation of the garrison." Now, is not Struensee's conclusion another proof of the defects of his method? since it commonly happens in war that a redoubt is constructed for less than

doubt; and secondly, because the work would not allow sufficient room for the detachment which its defence requires; the parapet is feebly manned, even when the length of the interior sides is 6 toises; for then 48 men are requisite for manning it properly, and experience proves that the redoubt can only contain 36. Hence it is evident likewise that no redoubt should be constructed for less than 36 men, or thereabout.

200 men who are to live in it? Besides, he is evidently incorrect, and inconsistent with himself, when, after establishing as a general principle that every soldier requires *at least* a space of 18 square feet, he asserts that the interior space of the redoubt will always be sufficiently capacious for the accommodation of the garrison, when it exceeds 200 men; for let it be 212, and yet the interior space of the redoubt will allow no more than 13 square feet, and 36 square inches to each man; the fact is, that the interior surface of a redoubt, constructed according to the directions of Struensee, will never allow a space of 18 square feet to each man, as he recommends, unless it is calculated for about 300 men, which shews still more obviously that his rule is bad.

Struensee's method is not more applicable to large than to small redoubts; for he augments the length of the interior sides, *e f*, *g h*, &c. in proportion to the number of men of which the garrison consists; and as the surfaces of redoubts, which are similar figures, increase as the squares of their sides, it follows, that by degrees those surfaces become immense and infinitely more considerable than they ought to be for containing their garrison: for instance, the interior surface of a redoubt constructed for 500 men and 4 guns by Struensee's method, is 18225 square feet, and I beg to ask whether such a surface is not ridiculously

large, when it is proved by experience that 10296 square feet are more than sufficient to contain easily the same number of men and pieces of cannon, nay, to afford proper lodging for the soldiers? According to Struensee himself, 9864 square feet are enough.

10. This author, and many others who have fallen into the same error, appear not to have perceived the disadvantage of constructing redoubts which have a surface much greater than is necessary to contain the detachments required for their defence; but in order to avoid it all experienced engineers justly recommend not to make any redoubt, not even a square one, whose interior sides shall much exceed 16 toises each, unless they are surrounded by a covert-way, or intended to contain a numerous artillery:* and in case the strength of the detachments should require longer interior sides, they prefer constructing works with flanks, which may defend their most exposed saliants and ditches.

11. Tielke, a captain in the Saxon artillery, proposes two methods: according to the first, the

* When the interior sides of a square redoubt are 16 toises each, it can, strictly speaking, be perfectly well defended by 384 men formed 3 deep, and contain 500 men; what would then be the case of a redoubt, the interior sides of which are much more than 16 toises? however, if your intention be to surround it by a covert-way, or to inclose a numerous artillery, you are

garrison being formed two deep, each file is allowed one pace,* each field piece four or five paces and the entrance eight paces: next, the sum of the several required numbers of paces is divided by four, and the quotient gives the length of one interior side: Lastly, two or three paces are added to this length, in order to compensate for the space which the banquettes occupy, (vide Tielke's Field Engineer, translated from the German into English, by Ensign and Adjutant Edwin Hewgill, in the Coldstream Regiment of Foot Guards, vol. 1, § 321, page 288.) I shall not anticipate what I propose to explain hereafter, by examining in this place whether Tielke may be right in laying down as a general rule, that 8 paces should be allowed for the breadth of the entrance of a redoubt, and 2 or 3 paces for the space which the banquettes occupy, and will only say that this method of Tielke has the same defects as that of Struensee; therefore, what I have said of the one, may be applied to the other.

Tielke, in his second method, multiplies the

obliged, of course, to augment its interior surface, in order to render it sufficiently large to contain the cannon, and not only the troops that are to man its parapet, but those also which defend the covert-way and will retire into the work when unable to resist any longer the efforts of the enemy.

* Tielke observes that a pace is equal to $2\frac{3}{5}$ Rhineland feet, and that the proportion of the Rhineland to the Paris foot is as $1391\frac{3}{10}$ to 1440.

number of men of which the garrison of the redoubt is to be composed by 18, and the number of field pieces by 216:* then, he adds the two products together and extracts the square root of their sum, which gives in feet the requisite length of one of the interior sides of the work, (provided they are equal,) or one fourth of the interior contour, (vide Tielke's Field Engineer, page 289, § 322.) Now I observe that redoubts constructed after this method are too small in general, especially when they contain artillery, and that the rule is applicable merely to a few redoubts thrown up for strong detachments: for, let it be applied to a redoubt calculated for 100 men and 1 field piece, the length of the interior sides will only be 7 toises and 2 feet, or thereabout, and such work is considerably too small for its intended garrison and artillery, since it is proved by experience that it can hardly contain 70 men without cannon.

I shall enter hereafter into further particulars respecting the defects of this method when redoubts are supplied with cannon, and only demonstrate at present that it is not generally suitable even to those which have no artillery; the reason is, that according to Tielke's calculations, the in-

* Tielke supposes, like Struensee, that every soldier requires a space of 18 square feet, and each piece of cannon, with its appurtenances, 216 square feet.

terior surfaces of all redoubts bear the same proportion to their garrison, whilst, on the contrary, the obstruction occasioned therein by the banquettes and their slope is so much greater according as the works are smaller: for example, let a square redoubt *a b c d*, pl. 3. fig. 10, be constructed by Tielke's method for 100 men: the length of each interior side *e f*, &c. will be about 7 toises, and if we suppose that 3 toises are taken off that length by the two opposite banquettes *n*, *o*, and their slopes *p*, *q*, the clear surface *i k l m* will contain 16 square toises, and allow about 5 square feet and 109 square inches to each man of the garrison. Now, let it be supposed that a redoubt has been thrown up according to the same method for 200 men, and that 3 toises are also taken off the length of the interior side *e f*, which is 10 toises, for the breadth of the two opposite banquettes *n*, *o*, and their slopes *p*, *q*: thus the surface *i k l m* which is not obstructed will contain 49 square toises, and each man of the garrison will have for himself about 8 square feet and 118 square inches of that surface; whence it is evident that the obstruction which the banquettes and their slopes occasion, inside the two redoubts, is much less in the latter than in the former,* and even admitting that the largest re-

* The reason of the difference in the obstruction which the banquettes and their slopes occasion in large and small redoubts

doubt can contain 200 men, it is no reason why the other can lodge 100: will it be objected that the banquettes and their slopes, on which some men can lay, afford a greater surface in a small than in a large redoubt, in proportion to the respective size of those works? this I shall admit, but shall deny that the greater surface afforded by the banquettes and their slope can compensate the obstruction which they occasion on the other hand, since experience proves the contrary.

12. The French officer of infantry Cessac Lacuée,* asserted in the first edition of his publication, entitled, *Le Guide de l'Officier particulier en Campagne*, that the parapet of a work should be as many feet long as there are men in the detachment: next, he recommended not to construct any enclosed work, whose interior contour is less than 80 feet; because should a smaller work be insulted with grenades or shells from howitzers, as the men could not throw themselves either to their right or left, they would suffer much from the rebounds and scattered pieces; he also considered

will easily be conceived, if it is considered that in general their dimensions do not vary considerably; whilst, on the contrary, the interior surfaces of those works are proportional to the squares of their sides.

* Cessac Lacuée never belonged, as many believe, to the corps of engineers in France, nor to the artillery; and when he published the first edition of his work, 5 or 6 years before the

240 feet, or 40 toises, as the greatest length which ought to be allowed to each of the interior sides of a redoubt. Cessac Lacuée, as it appears from his work, is no better geometrician than engineer, and he undoubtedly knew not that a redoubt, whose interior contour is 80 feet, can hardly contain the banquettes and their slope, whilst on the contrary a redoubt, the interior sides of which have a length of 40 toises each, can lodge a small army; some charitable person made him aware, most likely, of the absurdity of his rules, and he recommends, in the second edition of his work, the length of the parapet to be equal to as many times 18 inches as there are men in the detachment; he fixes also the minimum of the interior contour of enclosed works at 120 feet, and the maximum at 480 feet or 80 toises; (vide Le Guide de l'Officier particulier en Campagne, par M. Cessac Lacuée, nouvelle edition, revue et corrigée avec l'agrément de l'auteur, par. M. Mellinet, Adjudant Commandant et Sous-inspecteur aux revûes, page 14, § 24 and 25, and page 37, § 76.) I am under the necessity of saying, however, that these alterations in Cessac Lacuée's former ridiculous rules are far from recti-

French Revolution, he was a captain in the Dauphin's Regiment of Foot, which, as well as the Regiment of Artillery in which I served, was then in garrison at Metz, where I knew Cessac Lacuée personally. Mellinet who published the second edition of his work, is likewise an officer of the line.

fying their defects, as the works are still too small or too large, according to the strength of their garrison: for instance, let us suppose a redoubt calculated for 80 men conformably to Cessac Lacuée's improved method: the length of each interior side shall thus be 30 feet or 5 toises; but such redoubt is most undoubtedly a great deal too small for containing its garrison, since a redoubt whose interior sides are 6 toises, can hardly contain 36 men; on the other hand, the interior sides of a redoubt constructed by the same method for 320 men are 20 toises each, whereas it is proved by experience, as I have said in No. 10, note *, that a redoubt whose interior sides are 16 toises, or thereabout, can easily contain 500 men.

13. The French cavalry officer Lecointe does not display greater abilities as an engineer and geometrician than Cessac Lacuée: for he gives most extravagant rules in his publication entitled, *La-Science des Postes Militaires;* for instance, he allows 2 toises and 3 feet for the length of each interior side of a redoubt constructed for 30 men!!

14. Clairac, a French engineer, extracts the square root of the number of men who are to occupy the redoubt, and makes the length in toises of each interior side equal to it; this method may be applicable to redoubts calculated for very small detachments, but it is not suited to others, as it makes them too large: for instance,

a detachment of 100 men would require a length of 10 toises for each of the interior sides, whereas 8 toises and 3 feet or thereabout are quite sufficient.

15. I shall not speak of Lochée, as the work on field-fortification which he has published is merely a compilation from those of Tielke and Clairac, and contains of course the same errors.

16. The method proposed by Noizé de St. Paul, a French engineer, is better in general than any of the preceding; I shall observe, however, that it is rather complicated, as it varies according to the strength of the detachments: it contains, besides, several inaccuracies; but I shall only point out the two following.

This author says, No. 32, page 39, of his work on field-fortification, "if the detachment which "you intend to place in a redoubt is composed of "more than 90 men, and does not exceed 120, "take one fourth of the number of men for a re-"serve, which you may make equal to one-third "of that number if the detachment consists of "130 men or thereabout: then divide the remain-"der by 8, and the quotient will give the length "in toises, &c. of each interior side."—According to this rule, a detachment of 100 men requires that the length of the interior sides should be nearly 9 toises and 3 feet; whereas it is proved by experience, as I have stated before, that 8 toises and 3 feet, or thereabout, are enough; thus Noizé

de St. Paul's rule increases without necessity the size of the redoubt, which requires thereby more time and a greater quantity of materials for its construction:—besides, the author is inconsistent with himself; for he says, page 44, note *k*, in the same work, that a detachment of 100 men requires a redoubt whose interior sides should have from 8 to 9 toises *at most*. But let us proceed further, and suppose that the detachment consists of 120 men: according to the same rule, the interior sides of the redoubt should be 11 toises 1 foot and 6 inches: but Noizé de St. Paul recommends the same length for those of a redoubt constructed for 180 men; since he says, page 39, "if the number of men exceeds 150, as they will be able to man in 2 ranks the parapet of a redoubt capable of containing them, the length of the interior sides will be found by dividing the detachment by 16."* Now, why should a reboubt calculated for 120 men be exactly of the same size as a redoubt

* All detachments cannot man in 2 ranks the parapet of a redoubt sufficiently capacious to contain them; for, if we suppose a detachment of 60 men for example, as it requires a redoubt whose interior sides are about 7 toises, 56 men will be wanted for manning the parapet properly in one rank, No. 6; therefore the detachment cannot be drawn up 2 deep, since the men would be too far asunder, and the defence weak. No smaller detachment than about 160 men can afford 2 complete ranks for the defence of the parapet, and there will be no reserve.

constructed for 180? And is it not evident that Noizé de St. Paul's method, which may give satisfactory results in some other instances, is very defective in these two? Indeed it appears that he was aware of its insufficiency with regard to certain detachments; for he says, No. 32, page 40, "that he proposes it as a scale of comparison "which should be used merely as a guide in prac- "tice, since it is very difficult, not to say impos- "sible, to give a general rule of computing the "necessary length of the interior sides of redoubts "according to the strength of the detachments, "and that trying is the only way." I assert, however, that this author's work, in which he has collected and generally exposed with perspicuity most of the modern principles on which field-fortification is grounded, deserves no small degree of praise.

17. I have dwelt for some time on the several methods which I have been examining; first, on account of the importance of their object and the frequent use of redoubts in the field; secondly, in order to shelter myself from any charge of unfounded criticism; and have therefore deemed it necessary, not only to relate literally, as it were, the expressions of the authors of those methods, and to give references to their works, but also to apply the methods, in order to prove their defects more clearly: besides, discussion elucidates mat-

ters, and opens the way to the introduction of the true principles, which it renders more comprehensible. Lastly, as the works of Struensee, Cessac Lacuée, Tielke, &c. are circulating amongst young officers who may not perceive their defects, it is proper that they should be pointed out to them.

18. I now propose the following rule of my own, and assert that it is applicable to all sorts of detachments; I suppose the redoubts to be square, and that the garrison is to reside within them:*

1st. Multiply by 10 the number of men of which the detachment is composed, and the product will give in square feet the necessary extent of the surface contained between the foot of the slopes of the banquettes.

2d. Extract the square root of that product to one decimal,† and it will give in feet and tenths of a foot the length of one of the sides which enclose the above-mentioned surface.

3d. Add to this length twice the number of feet which the base of the interior slope of the parapet, the breadth of the banquette, and the base of its slope, are to have, according to the dimensions which I shall recommend in the 2d part of this work, and the sum will be the length in feet and

* I shall explain hereafter the method to be pursued with regard to circular and other redoubts.

† Sometimes it will suffice to extract the square root without decimals, as the difference will be trifling.

tenths of a foot of one of the interior sides of the redoubt.

Let us suppose, for instance, that you have to construct a square redoubt *a b c d*, plate 3, fig. 10, for 90 men: multiply 90 by ten, and the product 900 will shew that the surface *i k l m* which is contained between the foot of the slopes of the banquettes ought to be 900 square feet: extract the square root 30 of that product for the length in feet of the side *i k* which is represented by *a b* in the profile fig. 11, to which I refer the reader for the remaining part of the explanation: Now, supposing the base of the slope *c* of the banquette to be 6 feet, the breadth of the banquette *d* 3 feet, and the base of the interior slope *e* of the parapet 1 foot; multiply the sum of those dimensions by 2, and add the product 20 to the square root 30 which you have found before; then will the sum 50 be the length in feet of the interior side *e e* fig. 11, and *e f* fig. 10.

19. It is evident that in all redoubts constructed by this simple method, every man of the detachment has for himself ten square feet of the clear surface which is contained between the foot of the slopes of the banquettes; and I assert that 10 feet, in addition to the space afforded by the banquettes and their slopes, will suffice in all redoubts, let their size and figure be what they may: thus the redoubts will never be too small; it is obvious also

that they will not be too large in any instance:* therefore no doubt can rightly be entertained of the method being applicable to all sorts of detachments.

20. I have supposed in the preceding rule, that no artillery is to be placed in the redoubts; but should there be any, the length of their interior sides must undoubtedly be increased: Now I observe that the requisite augmentation depends, not only on the number of guns and their nature, but (and this is a very material consideration) on the size of the redoubts; and that it should be so much greater for a similar number of guns of the same sort, according as the works are smaller; the reason is, that as a piece of cannon and its appurtenances occupy the same space in a small as in a large redoubt, the obstruction which they occasion is far greater in the former than in the latter: it is therefore ridiculous to pretend, like Struensee, Tielke, Cessac Lacuée, and most of the authors who have written on field-fortification, that in all redoubts the same number of feet should be added to the length of the interior contour of the parapet for each piece of cannon; because a trifling augmentation to that length will suffice for placing artillery in a large redoubt, whereas it is

* The reader has been told that the banquettes and their slopes have dimensions which in general do not vary considerably.

necessary to increase it considerably if the redoubt be small. Indeed Tielke recommends a different method when the garrison is to dwell in the work: No. 11. But this method has the same defects as the other, with regard to redoubts of no great extent: namely, it does not sufficiently increase the length of their sides; and it is applicable only to some large redoubts. The following rule, I trust, will answer in all cases.

"Multiply the number of men who are to be placed in the redoubt (the artillery men included) by 10, and the number of guns by 324; extract the square root, to one decimal, of the sum of the two products, and add to it twice the number of feet which you allow to the base of the interior slope of the parapet, the breadth of the banquette, and to the base of its slope; then the sum will be the length in feet and tenths of a foot of one of the interior sides of the redoubt."*

* According to this rule an additional surface of 324 square feet for each gun is allowed to redoubts, which may appear considerable; I do not believe, however, that a smaller allowance can prevent their being obstructed by the cannon, and particularly when the redoubts are small.

Noizé de St. Paul augments still more than my method does, the surface of small redoubts, when they are to contain artillery: for he asserts in his work, page 38, *note*, that the length of the interior sides of a redoubt thrown up for 50 or 60 men, should be at least 9 or 10 toises, instead of 7, if the redoubt is to

21. I now proceed to explain the method of tracing the interior sides of square redoubts.

Let it be required to construct a square redoubt *a b c d*, pl. 3, fig. 10, in order to defend a defilé, a bridge, &c.—trace one of the interior sides *e f* in the direction most suitable to the ground and your intended object, and after having computed its requisite length, according to the number of men and pieces of cannon which are to be placed in the redoubt, Nos. 18 and 20; next, at the extremities *e* and *f* of *e f*, erect the perpendiculars *e h* and *f g* equal to it; lastly, join *h g*, and the interior sides of the redoubt will be traced.

22. Square redoubts are more simple and easy to construct than any other; but the configuration of the ground, and the number and situation of the points which a redoubt may have to defend, &c. frequently require that its figure should not be square; in this case, plant staves at all the points where, in your opinion, the vertex of the angles formed by the interior sides of the work can be placed to the greatest advantage, and after

contain one gun: such an immense augmentation, however, appears to me not only useless, but prejudicial to the defence, as the parapet is then thinly manned; besides, it follows from his assertion, that a redoubt, whose interior sides are 10 toises in length, cannot contain more than 50 or 60 men and 1 gun, which is wrong.

taking, with the plain table, or by any other means which you have at hand, the plan of the figure delineated by lines which you suppose to join those staves, consider it as representing the interior contour of the parapet: measure the angles formed by those lines, in order to ascertain whether they are sufficiently open, Max. 1, and if some are not rectify them: inside of the plan draw a parallel to its outline, and at a distance from it equal to the number of feet which you intend to allow to the base of the interior slope of the parapet, the breadth of the banquette, and to the base of its slope: and as the figure described by this parallel represents that of the space which is contained between the foot of the slopes of the banquettes, compute its area in square feet, and proceed as it shall be explained in No. 25; if it appears from your calculations that the redoubt will be considerably too large, according to its garrison and artillery, this defect may be remedied by shortening the interior sides or diminishing their number when it exceeds four, or by giving a smaller opening to the angles: but if the work is small beyond measure, the contrary should be done.

23. Should a redoubt be circular, compute the radius of the circle bounded by the foot of the slope of the banquette, so that the enclosed surface may allow 10 square feet to each man, and 324 square feet to each piece of cannon: add to this radius

twice the base of the interior slope of the parapet, twice the breadth of the banquette, and twice the base of its slope: then drive a picket at the centre of the redoubt, and fasten to it one end of a cord equal to the radius thus increased; and with the other end, to which a pointed picket is fastened, describe a circumference upon the ground.

24. I have recommended the use of the plain table for taking the plan of irregular and polygonal redoubts, and shall now observe that all sorts of right lined figures can also be easily and quickly traced on the ground with that instrument.

For instance:—Let it be required to trace on the ground, with the plain table, the figure A B C D E, pl. 3. fig. 15, a plan of which is given: fix on the table the given plan *a b c d e*, fig. 13, and place the instrument at any point A on the ground which corresponds to the point *a* on the plan: lay the index at *a* according to the usual method in surveying; and turn it successively towards the points *b*, *c*, *d*, and *e*: plant staves at B, C, &c. in the direction of *a b*, *a c*, *a d*, *a e*, and at a distance from A equal to the length of the lines *a b*, *a c*, &c. Lastly, join A B, B C, &c. and the required figure will be traced.

I have always found the plain table very useful in the field, where many operations can be performed with it, which are frequently required; in-

deed I am sensible of its defects, should great precision be requisite, but this is seldom the case in war, as rapidity of execution is particularly desirable, and no greater accuracy wanted in general than that which the plain table can afford. This instrument, especially when it is calculated for military purposes, should be simple, cheap, easy to handle and carry, and not liable to be deranged by trifling accidents which happen commonly.

When the French use the plain table in surveying, they fix the direction of the magnetic meridian by means of an instrument which they call DECLINATOIRE; it is a small rectangular box, such as represented fig. 16 and 17, the breadth of which is about one half or one third of its length: it contains a magnetic needle supported by a pivot which is placed perpendicular to the bottom of the box, and at the centre of it: the magnetic needle is not surrounded by a circle of metal divided into degrees, as in a common compass, but it indicates only North and South by means of a line or point that is placed on the middle of the short sides of the box, the long sides of which are parallel to the needle, and consequently give the direction of the magnetic meridian, when, the box being laid horizontally, the ends of the needle correspond with the lines or points which are placed on the middle of the short sides. I prefer the declinatoire to the common magnetic needle and com-

pass, as it is not so liable to be broken or deranged; besides, as the needle is confined within a smaller space, it cannot move about so much, and is sooner fixed.

25. I shall now explain the method of ascertaining how many men and guns a redoubt which is constructed can contain.

" Compute the area in square feet of the surface contained between the foot of the slopes of the banquettes, and divide it by 10, if no artillery is to be placed in the redoubt; the quotient will give the number of men that can be lodged in the work: but should the redoubt be supplied with cannon, substract 324 square feet for each piece from the above area, and divide the remainder by 10, which will give the number of men.

OF REDOUBTS EN CREMAILLERES.

26. Although it was proposed by the French engineer *Lafon*, as long ago as 1740, to construct *cremaillères, a e b, b f c*, &c. pl. 4, fig. 18, for defending the saliants of works which are not flanked, I do not know any instance of their having been used in the field for that purpose. Most authors who treat of field fortification mention them in their writings, yet no one says that he has constructed them, or seen any constructed,

and hence this ingenious contrivance, which might be of great utility if properly applied and circumscribed by certain limits, seem to be amongst those which are known only in theory: nay, I will venture to assert, that many engineers have had a very wrong idea of cremaillères, as it appears from the absurd methods proposed for constructing them which we find in most of the works written on field fortification, and from the common erroneous opinion that the faces and saliants of field works can be defended at the same time by their means, which is impossible.

I shall not enter at present into any further details respecting cremaillères, as the reader might not understand easily what I propose to say concerning them, until he is first made acquainted with principles which cannot be explained in this place, without deviating from the proper and intended order of the subjects contained in this work.

OF FORTINS, OR FIELD-FORTS.

27. Two kinds of *fortins* or *field-forts* are most generally used, when the ground, the intended object of the work you have to construct, and the strength of its detachment will allow you to make it regular, or nearly so; these are the

forts with tenailles or *star-forts*, and the *forts with bastions*;* but sometimes you are compelled to construct a fort which is composed of different figures at once, and in this case no particular name can be given to it.

Field-forts take a particular name also from their number of saliants; thus, a fort is said to be square, pentagonal, or hexagonal, &c. according as it has four, five, or six saliants.

OF FORTS WITH TENAILLES, OR STAR-FORTS.

28. *Forts with tenailles* or *star-forts* are so called from their contour, which being composed of lines making alternately saliant and re-entering angles, gives them the figure of a star: indeed, these forts are nothing more than square or polygonal redoubts, whose sides are broken, by which I mean, that those sides, instead of being straight, as *a b*, *b c*, pl. 4, fig. 19, form a re-entering angle *a e b*, which is called *angle of the brisure*; the sides *a e*, *b e*, are named *sides of the brisure*.†

* I do not here mention the *forts with demi-bastions*, as I shall demonstrate hereafter that they ought to be entirely rejected.

† The angle *a e b* is also called *angle of the tenaille*, and its sides *a e*, *b e*, *sides of the tenaille*.

Although all star-forts give a cross fire upon the ground in front, yet they are not all equally capable of making a good defence, and the degree of resistance they afford depends on the opening of the angles of the brisure, which is determined by the number of saliants: for, let *a e b f*, &c. be a square star-fort, pl. 4, fig. 19: as the angle at the circumference of a square *a b c d* is only 90°, and since you ought not to allow less than 60° to the saliants *a*, *b*, Max. 1, the angle of the brisure *a e b* will be 150°; and on account of the great obtuseness of this angle, the fire of the sides of the brisure *a e*, *b e*, will afford no better protection to the saliants *a*, *b*, than the fire of the straight side *a b* of a common square redoubt; nay, the undefended sectors in front of these saliants, No. 5, note*, will be greater by the sectors *k g*, *h l*, as the figure shews: besides, as the opening of the saliants is small, it is scarcely possible to construct within them any defences peculiar to them, such as cremaillères, &c.; therefore, a square star-fort has not only no superiority in general over a square redoubt, whose sides are straight, but is greatly inferior to it: there is one case, however, in which the former is preferable to the latter: namely, when its saliants can be refused to the enemy, and the ground *i* only, in front of the angle of the brisure, is exposed to his attacks; for this ground will be more effectually protected by the cross fire

of the sides of the brisure, than by the direct fire of the straight sides of the redoubt; and, as it has been supposed, on the other hand, that the saliants cannot be attacked, it is very immaterial whether they are protected or not.

29. A pentagonal star-fort, plate 4, fig. 20, is nearly as defective as a square one; for, since the angle at the circumference of a pentagon is only 108°, that of the brisure *a h b* should be 132°, in order that the saliants *a*, *b*, may contain 60°; wherefore, the angle of the brisure being still very obtuse, the saliants are not more defended by the fire of its sides, than those of a square star-fort; indeed, that fire crosses a little better upon the ground *i* in front, but this is the only advantage which a pentagonal star-fort possesses over a square one, and it ought to be employed, in general, only when its saliants can be refused.

30. As the angle at the circumference of a hexagon is 120°, the saliants *a*, *o*, of a hexagonal star-fort, pl. 4, fig. 21, will not be less than 60°, when the angle *a m o* of the brisure is only 120°; therefore, the fire of the sides *a m*, *m o* will cross better upon the ground *r* in front, than in the square and pentagonal star-forts: the space *p q*, before the saliants, which is not defended by that fire, will also be smaller; however, as it will still be sufficient to enable a column of 20 or 24 men abreast to approach the saliants without danger,

I conclude, that in this, as well as in the square and pentagonal star-forts, the saliants should be out of insult.

31. The defects which I have examined in the preceding forts are less in a heptagonal star-fort, pl. 5, fig. 22: as the angle at the circumference of a heptagon is about 128°, the angle *i b m* of the brisure does not require more than 112°, that the saliants *i*, *m*, may retain a sufficient opening; hence, not only the ground *r* before that angle is well defended, but the fire of the sides *i b*, *b m*, of the brisure crosses in front of the saliants and protects them; thus, a heptagonal star-fort might prove of some service, although its saliants could not be refused; but nearly as much time and labour is required for its construction as for that of an octagonal one, pl. 5, fig. 23, the length of the sides of the brisure being supposed to be the same in both, and the defence which the latter affords is far superior to that of the former: for, as the angle at the circumference of an octagon is 135°, the saliants *a*, *n*, are sufficiently open, when the angle of the brisure *a m n* contains 105°; hence, it follows, that the ground *o* in front of the brisure is extremely well defended: nay, that even the saliants receive an effectual though incomplete protection, Max. 4, from the sides of the brisure, whose fire crosses at no very great distance from them.

32. With regard to star-forts, which have more than 8 saliants, they possess this undoubted advantage over an octagonal star-fort: namely, the fire of the sides of the brisure crosses still nearer to the saliants;* but this advantage, however considerable it may be, is overbalanced by inconveniencies arising from it; and I shall lay it down as a principle, that in general a star-fort ought not to have more than 8 saliants.

33. I have demonstrated that star-forts acquire greater strength from their number of saliants being greater: but I now remark that you can not always regulate at pleasure the number of saliants, the length of the parapet remaining the same: first, because the ground may prevent it: secondly, because the angle of the brisures become more numerous and re-entering, according as the fort has more sides, and diminish therefore, in a greater proportion, the surface of the polygon circumscribed to the fort which may become too small for its detachment: thus, even supposing that the ground will allow you to construct a star-fort of any number of sides, an octagonal one, for instance, you ought to consider whether the re-

* The reason is obvious, since the greater the number of saliants, the smaller the angles of the brisure become, the opening of the saliants remaining the same.

quired length of the parapet for the number of men of which the garrison is to consist will enclose a surface capable of containing them, notwithstanding the diminution occasioned by the angles of the brisures; when it will not, you ought to reduce the number of sides, if circumstances permit, (see Nos. 28, 29, 30, 31,) or give up the idea of constructing a star fort.

Besides it is to be observed that the length of each side of the brisure should be 7 toises at least: the reason is, that should those sides be smaller, their fire would be so weak as to prove of no effect; and had the work a certain relief, and the parapet a certain thickness, the ditch would be entirely destitute of actual defence, as its bottom would not be seen from the flanking part, even near the saliants: on the other hand, no greater length should be given to the sides of the brisure than about 16 toises each, as the fort would acquire an immense interior surface, in proportion to the number of men requisite for its defence; an octagonal star-fort, for instance, which may be properly defended by 1440 men, 3 deep, the sides of the brisure being 15 toises each, can contain more than 3000: besides, should they much exceed 16 toises, the construction of the fort would require much time and a great quantity of materials, and the lines of defence would be very long; indeed,

some irregularities of the ground and the intended object of the work, &c. may compel you sometimes to deviate a little from the dimensions which I have recommended, and the fort be equally good; but, should you deviate from them much, it would then be better to abandon the intended construction of a star-fort, and throw up some other works.

34. I shall here remark by the way, that few circumstances occur in the field, where you can construct works perfectly regular, since not only the ground and intended object of the work you throw up, but also the facility or difficulty which the assailants have of attacking it on certain points, &c. require very often greater or less irregularities, which, as the reader may see, vary without end; young engineers, therefore, ought to consider the regular constructions given by authors, merely as guides which are to direct them in practice; and when acquainted, not only with those constructions, but also with the principles upon which they are founded, the nature of the ground and their *coup d'œil* ought to shew them in what manner and how far they may deviate from a strict regularity, in order that the work which they have to throw up may best answer its intended object.

35. The following is a general and convenient method for tracing all sorts of star-forts, as high as the dodecagonal inclusive,* provided that the saliants can be placed at pleasure; for, should their position be determined by the ground, the tracing ought to be adapted to it, and to the nature of the polygon, care being taken that the saliants and angles of the brisures may retain a proper opening, Max. 1 and 4; this is the rule: describe a regular figure whose number of sides shall be the same as the number of saliants which the fort is to have: a heptagon *a b c d*, &c., for instance, pl. 5, fig. 22, and make those sides *a b*, *b c*, &c. equal to the length which you allow to each side of the brisure: then describe on *a b*, *b c*, an equilateral triangle as *e h f*.

Most of the authors who have written on field-fortification, recommend also to trace star-forts as follows:

For tracing a square fort, pl. 4, fig. 19; construct a square *a b c d*, and bisect each side as *c d* by a perpendicular *m n* equal to $\frac{1}{8}$ *c d*: then, through the extremity *n* of that perpendicular, and the ends *c* and *d* of *c d*, draw *c n* and *d n* for the

* By this method, the saliants are invariably 60°; but if we suppose that a star-fort has 12 saliants and each contains 60°, the angles of the brisures will be right angles; therefore, more than 60° ought to be allowed to the saliants, should their number exceed 12, as the angles of the brisures would be less than 90°, contrary to Max. 4.

sides of the brisure: *c n d* will be the angle of the brisure.

If you have to trace a pentagonal star-fort, pl. 4, fig. 20, describe a pentagon *a b c d e*, and bisect each side as *e d* by a perpendicular *f g* equal to $\frac{1}{6}$ of *e d*: then draw *d g* and *e g*.

As for a hexagonal star-fort, pl. 4, fig. 21, make an equilateral triangle *c a b* and divide each side as *b c* into 3 equal parts: take every central division as a base, and construct on it, as on *d e*, an equilateral triangle *d f e*.

If the fort is octagonal, pl. 5, fig. 23, describe a square *a b c d*, and bisect each side as *c d* by a perpendicular *e f* equal to $\frac{1}{8}$ of *c d*: then set off from *f* to *g* and from *f* to *h* $\frac{1}{6}$ of *c d*, and construct a redan *g i h*, whose sides *g i* and *h i*, are each equal to *g h*.

The following method for tracing an octagonal star-fort has also been proposed by many engineers: describe a square *a b c d*, pl. 5, fig. 24, and divide each side as *c d* into 3 equal parts: on each central division make an equilateral triangle as *e g f*; but this construction has the defect of leaving in front of 4 saliants a space *i h* which is defended by no direct fire except the single shot *o s*.

I shall repeat that of star-forts, the octagonal is, in general, the best which can be constructed: the resistance it can make will answer in most cases the intended object of a field-fort, and, when it is constructed according to rule, its surface is

sufficiently capacious for containing a garrison which allows you to construct in its front *flêches, places of arms,* &c. if no particular circumstance prevents it;* for, even supposing the sides of the brisure to be only 7 toises each, the fort can be properly defended by 448 men two deep, and can contain 600.

36. Star-forts can afford, no doubt, a better defence than common redoubts, when they have more than 6 saliants; but they require much time, care, and labour in their construction, the difficulties of which are sometimes augmented by the ground; therefore, you ought not to use them indiscriminately, but in such particular cases only, as require a work with flanks and able to make a stronger defence than a simple redoubt.

OF FORTS WITH DEMI-BASTIONS.

37. Owing to an old prejudice, some military men still believe that forts with demi-bastions can afford a better defence than star-forts, and are a sort of intermediate class between them and the forts with bastions; forts with demi-bastions, how-

* These secondary defences may answer, in some cases, a very good purpose: namely, they serve to keep off the assailants, and give an additional support to the saliants, which, as I have observed, No. 31, are not perfectly protected by the fire of the sides of the brisure; but, you cannot use them in all circumstances, as I shall explain hereafter.

ever, far from possessing any superiority over star-forts, are greatly inferior to them; especially when they are not constructed on a polygon of a great many sides: which I shall demonstrate after having first explained the usual method of tracing them; I shall begin with the triangular fort.

For tracing a triangular fort with demi-bastions, pl. 5, fig. 25, calculate what the length of the parapet ought to be, according to the strength of the garrison, and number of guns; then describe an equilateral triangle *a b c*, and make the sum of its sides equal to $\frac{3}{4}$ of that length: divide each of those sides into 3 equal parts, and after producing them, set off from *a* to *f*, from *c* to *d*, and from *b* to *e*, one of those 3 parts: next, through *e* and *a*, *f* and *c*, *d* and *b*, draw *e a*, *f c* and *d b*: lastly, make *b i*, *a g* and *c h*, each equal to $\frac{1}{3}$ of the side *a b* of the primitive equilateral triangle *a b c*, and at the points *i*, *g* and *h* erect the perpendiculars *i m*, *g k* and *h l* cutting *e a*, *f c* and *d b*: these perpendiculars will be the flanks of the demi-bastions, and *f i m e h l d*, &c. the outline of the fort.

By this construction, 1st, the saliants *d*, *e*, *f* are only 46° or thereabout, and therefore the demi-bastions are so narrow, that no defensive manœuvre can be executed within them: 2dly, a triangular figure has little surface, in proportion to its contour, as every reader knows; and in order that a triangular fort with demi-bastions may contain the

detachment requisite for its defence, its sides, as also the lines of defence, require a great length: 3dly, the approach to the faces of the demi-bastions, to the face *e m*, for instance, and particularly its ditch, are not defended, as many believe, by the pretended second flank *a f:* for even supposing the length of the side *a b* of the primitive triangle to be 60 toises, and the breadth of the parapet only 10 feet, the line of defence *e a* being produced meets the interior side *r t* of the parapet of the curtain at its extremity *r:* and as the fire does not come from *a f*, which is part of the exterior side of the parapet, but from the interior side *r t*, it follows that there is no second flank; thus, in order to have one, the side *a b* ought to be longer than 60 toises; but, should it considerably exceed that length, in order that the second flank may be of a certain extent, then the sides of the fort would be enormously long, its figure immense, and the lines of defence would exceed musket shot; besides, what protection could the face *e m* and its ditch receive from the second flank, as the angle which it makes with the line of defence is obtuse beyond measure?*

* A second flank can also be procured by giving to *e a* a direction less oblique and making it meet the curtain at some point *s*, as may be seen by the dotted line *e s;* even this construction improves the second flank defence, which it renders less oblique: but it has the great defect of making the demi-bastions still narrower, and utterly uninhabitable.

It is obvious also from what I have said, that the saliant *e* is only protected by the single flank *h l:* so that the assailants can approach it in a column, and without any danger, by availing themselves of the ground *p q*, which is not defended; the assailants, when arrived at the ditch where they have not to fear a single shot, will spread themselves therein along the face *e m*, the flank *i m*, and such part of the curtain *i f* as is not seen from *i m:* and after forming in good order, they will give the assault to the demi-bastions. Let us conclude from the preceding observations that the triangular form is not suitable to forts with demi-bastions, and that this defective construction (which I should not have mentioned had it not been for the purpose of cautioning the reader against the praises so erroneously bestowed upon it by many authors) ought to be entirely rejected.

38. For tracing a square fort with demi-bastions, pl. 6, fig. 26, construct a square *a b c d*, and make the length of each side *a b*, &c. neither less than 40 toises, nor more than 100,* according to the strength of the intended garrison: bisect each side as *c d* by a perpendicular *e f* equal to $\frac{1}{8}$ of *c d:*

* The demi-bastions, and particularly their flanks, are very small, even when the length of the sides *a b*, &c. is 40 toises; on the other hand, should this length exceed 100 toises, then the lines of defence would be too long, and the musketry fire have no effect.

Draw the lines of defence $c f$ and $d f$: set off from d to g $\frac{2}{7}$ of $c\ d$, for the length of the face $d\ g$ of the demi-bastion, and from g let fall the perpendicular $g\ h$ to the line of defence $c\ f$ produced; $g\ h$ will be the flank.

39. With regard to forts which have more than 4 sides, the method of tracing them is much the same; with this difference, however; that instead of a square you ought to trace first a polygon of the number of sides which the fort is to have; and in order to diminish the obliquity of the second flank defence, a greater length is given to the perpendicular $e\ f$, according as the polygon has more sides; in the pentagon, for instance, $e\ f$ is made equal to $\frac{1}{7}$ of $c\ d$, and in the hexagon and upwards, to $\frac{1}{6}$.

The resistance which a square fort with demi-bastions can make, does not much exceed that of a triangular fort; for, as the angle $o\ n\ b$ which the second flank $o\ n$ makes with the line of defence $n\ b$ is still very obtuse, the approach to the face $p\ b$ of the demi-bastion is feebly impeded by that second flank: and although the ground $i\ k$ which is not defended by any direct fire is less in a square than in a triangular fort, it is sufficiently wide for allowing a column on a large front to approach the saliant b without risk: it is evident likewise that this saliant receives no direct defence but from the flank $l\ m$: in short, a square fort has this advan-

tage only over a triangular fort: namely it contains a greater surface, the length of the parapet being the same, and its appearance is more imposing; on the other hand, its construction requires considerable labour which is not compensated by the defence it can afford.

40. The defects in the square and triangular forts which I have been analyzing, diminish, according as the polygon on which forts with demi-bastions are constructed has more sides; these forts acquire a surface progressively greater compared with their contour, and as the obliquity of the second flank defence decreases more and more, the approach to the faces of the demi-bastions is better and better defended; however, as forts of this kind cannot make any good defence unless they are constructed on a polygon of a great many sides, which requires considerable labour, it is far preferable, when you have the means of throwing up an important work, to construct a fort with bastions, the tracing and advantages of which I shall explain.

OF FORTS WITH BASTIONS.

41. Forts with bastions have not commonly more than 4 or 5 sides, and should not have less than 4; they are used, in general, for covering some important point, as they produce the same effect,

in some measure, as a small fortress or an intrenched post.

For tracing a square fort with bastions, pl. 6, fig. 27, describe a square *a b c d*, and make its sides *a b*, *b c*, &c. neither less than 60 toises each, nor greater than 100;* unless you are compelled by the ground to exceed the latter length by a few toises: bisect each side as *a d* by a perpendicular *e f* equal to $\frac{1}{8}$ of *a d*, and draw the lines of defence *a f* and *d f*: then set off $\frac{2}{7}$ of *a d* from *a* to *g* and from *d* to *h* for the length of the faces, and describe the flanks by letting fall from the points *g*, *h*, the perpendiculars *g k* and *h l* to the lines of defence produced: lastly, join the extremities *k* and *l* of the flanks by the curtain *k l*, and the outline of the fort will be traced.

The reader can see by the figure, that the whole ground in front of the fort is exposed to a cross fire, and that the assailants cannot approach the work without being seen in flank, which proves the advantages of forts with bastions.

Should you have to trace a pentagonal fort, the defence of which is superior to that of a square, describe first a pentagon, and then proceed in the

* Should the sides of the figure upon which a fort with bastions is constructed be much less than 60 toises each, the bastions would be too narrow and their flanks too small; on the contrary, should they greatly exceed 100 toises, the lines of defence would be too long, and the flanked angles feebly protected by the musketry fire of the flanks.

same manner as for a square fort, with this difference only: the perpendicular which bisects each side of the pentagon, ought to be equal to $\frac{1}{7}$ of that side; for a hexagonal fort, it should be equal to $\frac{1}{6}$.

42. In order to procure additional strength to forts with bastions, means have been sought for directing towards the flanked angles, which are the weakest points, part of the fire of the curtain, which, being re-entering and placed between two flanks that cross their fire in its front, is inaccessible in some measure; for this purpose it has been proposed to break the curtain in the following manner: from the intersection *m* of the lines of defence, pl. 6, fig. 27, set off *m n* and *m o* equal each to $\frac{1}{6}$ of the curtain *r s:* join *n o*, and the broken curtain will be *r n o s*; by this construction, *n r* and *o s* carry their fire towards the flanked angles *d*, *c*, and *n o* defends directly the ground in its front.*

I shall not enter into any further details respecting field-forts with bastions, the tracing of which is nearly the same as in permanent fortification,

* Sometimes also, the curtain is broken in such a manner as to make an angle *u t v*, pl. 6, fig. 27; its vertex is placed at the intersection *t* of the lines of defence, the parts *u t* and *t v* of which form its sides; by this construction a greater quantity of fire is directed toward the flanked angles *b* and *c* than by the former, but it leaves an undefended sector of a circle *y t x* in front of the curtain, and I prefer the other method.

as the reader has seen; I shall only observe that their construction requires much care, precaution, and labour; consequently they ought to be reserved for particular cases which require a work capable of making a strong defence.

OF TETES DE PONT.

43. *Têtes de pont* are thrown up for covering a communication across a river, and favouring the movements of an army or detachment, either when advancing into the enemy's country, or retreating from it.

The form, size, and strength of a tête de pont ought to be regulated according to various circumstances, and before you fix upon them it is necessary to consider: 1st, the importance of the communication which it is to cover, and the probable length of time, during which the communication is to be kept up: for, its utility may be confined to a temporary movement of the troops, or extended to the sequel of operations for a long time:* 2dly, the breadth and form of the river at

* When têtes de pont of this kind are intended to protect a communication for large bodies of troops, they take the name of *grandes têtes de pont;* I shall treat of them in the third part of this work, and will confine myself for the present to common têtes de pont.

the point where the tête de pont is to be thrown up; and, likewise, the nature of the country on both banks; 3dly, whether the tête de pont can be supported by musketry from the opposite banks, or by artillery only, or by neither: 4thly, whether the river has only one arm, or forms an island; and in this case, what is the breadth of its arms, and the form of the ground in the island itself, so that you may determine with more certainty the defensive dispositions which can be made to the greatest advantage: 5thly, when you are to construct a tête de pont for covering the retreat of an army, or strong detachment, you ought to consider, whether, according to their composition and the state of things, that retreat is likely to be executed with celerity or slowness; whether there is any fear that the retreating troops will be closely followed up by considerable forces, or whether they can retire quietly, and without being exposed to any attack which may endanger them: 6thly, and lastly, you ought to examine what is the strength of the army, or detachment, its number of cannon, the quantity of stores, and *equipage*, *&c.* and regulate accordingly the size of the tête de pont, as well as the passages through it, in order that the whole may file off without stoppage and confusion; all these various circumstances oblige us to make a difference in the size, form, and strength of a tête de pont. If an army, or considerable detachment, for in-

stance, is closely pursued by a great force, and can retreat but slowly, either on account of its composition, or because it is compelled to take particular precautions, which require time, the tête de pont, which is intended to favour its passage across the river, ought to be of a certain extent, and capable of making a good defence; for then, not only the troops, artillery, &c. must file off through it without any obstruction or confusion, but it ought to check the enemy, should he attempt to approach it: on the contrary, if a tête de pont has to cover a communication of no great importance, or the passage across a river of an army or detachment which is not closely pursued, and can retreat quietly and speedily, it will not require as much extent and strength as the former.

It is obvious from the preceding observations, that all cases cannot be foreseen, and a rule given for every circumstance;* therefore, I shall content myself with describing, in a general way, such regular têtes de pont as may be thrown up to the greatest advantage, on the most frequent occurrences; but I shall first observe, that the bridge or bridges, which a tête de pont covers, should be concealed as much as possible from the enemy's

* It is impossible, likewise, to fix invariably the dimensions of the several parts of a tête de pont, since its extent depends on various circumstances.

sight, as he would batter and ruin them with his cannon; and that, in general, the most advantageous points for constructing those works, are where the river bends inwards.

44. When a tête de pont is to cover only a communication of no great importance, and across a small river, a simple redan, such as represented by fig. 28 and 29, pl. 6, will suffice: provided, however, that the river is so shaped as to prevent the enemy perceiving the bridge *f* from some point *a* or *b*; but if he can perceive it, a piece should be constructed, fig. 30, whose flank *a b* defends the ground *c* from which the bridge *f* can be seen. These small têtes de pont will acquire a greater strength, if the ground on the opposite bank allows us to construct small redans, *d*, fig. 29 and 30, where fusileers are placed: these redans ought to be disposed in such manner, that their fire, after grazing the faces of the tête de pont, may cross in front of the saliant, and as near to it as possible; the redan *e*, fig, 30, is intended to graze the flank *a b* of the piece, as the figure shews.

45. When the river is so broad as to prevent the musketry fire of the redans *d* doing any execution for the defence of the tête de pont, batteries may be constructed and disposed in the same manner as the redans.

46. A tête de pont, which is intended to cover a communication of importance, and necessary for

the movements of large bodies of troops, requires a greater extent and strength than the preceding. That represented by fig. 31, pl. 7, is capable of making a good defence, particularly when it can be supported by batteries *a*, placed on the opposite bank; its outline does not differ widely from that of a redan, except that the faces are broken in order to procure the two flanks *b c* and *d e*, the direction of which ought in general to be as perpendicular as possible to *e f* and *d f*, which they defend. Care must be taken, however, that they are not exposed to be enfiladed, which depends, of course, on the configuration of the river, and the disposition of the surrounding ground.

Sometimes, also, a tête de pont may be composed of a *horn work*, fig. 32, the inside and branches of which are defended by batteries *a*, erected on the opposite bank. When the ground does not allow you to construct these batteries, the branches of the horn work should be broken, as in fig. 33, in order to procure the flanks *a b*, *c d*, which, the same as *b c*, *d e*, fig. 31, ought to be as perpendicular as possible to *e b* and *c f*, without being exposed to enfilade.

Half a *square fort with bastions*, fig. 34, makes a strong tête de pont, particularly when you can construct on the opposite bank batteries *a* and intrenchments *b*, as in pl. 8, fig. 35. Half a *star-*

fort, or redoubts so disposed as to flank each other, may also be used for a tête de pont.

47. The têtes de pont *en cremaillères* represented by fig. 36 and 37, pl. 8, can make likewise a very good defence, particularly when they are flanked by batteries *a* from the opposite bank: the cremaillères must be so disposed as to leave a free passage for the troops, and no aperture which may enable the assailants to see into the work, and perceive the bridge. I shall explain the construction of cremaillères when I treat of intrenchments of armies.

Fig. 38 represents a tête de pont constructed on the bank of a river which forms an island where intrenchments *a* have been thrown up. The work would acquire an additional strength, should intrenchments be also constructed on the bank *b*.

It has been explained that an army or detachment retreats through a tête de pont by means of passages cut across its parapet: these passages should be placed in the least exposed parts of the work, and as well flanked as possible.

48. When the importance of the communication covered by a tête de pont requires that it should afford a strong defence, a small work *m*, pl. 7, fig. 31, 32, &c. is usually constructed within it; these small works ought to be so disposed as to cover the bridge or bridges, and

defend the interior of the main work; when the whole of the army or detachment has reached the other side of the river under the protection of the tête de pont, its garrison retreats likewise, and is supported by the fire of the small works *m*, where such a number of men is placed as is requisite for their defence; these men ought to hold firm till the bridges are taken up, and then cross the river in boats. During the retreat of the troops, an incessant and powerful fire should also be kept from the opposite bank of the river.

OF INTRENCHMENTS OF ARMIES.

49. They call *intrenchments of armies* the whole of the works and obstacles by which an army or a considerable body of troops cover themselves for their own defence, and, in general, for the purpose of interposing between themselves and the enemy a defensive line, whose protection may compensate for their inferiority in number; this line may be composed of parts so connected together, that no uncovered space is left between them, in which case it is called a *continued line;* or those parts may be isolated from each other, and uncovered intervals left between them; and then it is named a *line with intervals.*

50. Intrenchments of armies can seldom be composed of regular and similar works, nor even of

works different in their nature, but symmetrically disposed and so constructed that all those of the same kind may have the same dimensions; for, on account of the ground, or because of a necessity to direct more fire to certain points than to others, some irregularities will be requisite; thus it is impossible to foresee all the variations that may occur in the tracing of intrenchments of armies, wherefore no particular rules can be given for every case; there are, however, general principles, which ought to guide an engineer, and which shall be laid down when I explain the method of applying field-fortification to the ground; and I will confine myself for the present to explaining and analyzing the construction of the works which, according to localities and circumstances, are most generally used for regular intrenchments: at first I shall suppose the line which they form to be a *continued line.*

OF CONTINUED LINES.

51. The works most commonly used for intrenchments of armies in a *continued line*, are *redans, tenailles*, or *queues d'hironde*,* *cremaillères* and *bastions;* hence intrenchments take the name of *intrenchments with redans, intrenchments with tenailles*, or *queues d'hironde, intrenchments with cre-*

* There are *queues d'hironde* of various figures as will be seen hereafter.

maillères and *intrenchments with bastions;* sometimes also *lunettes* are placed in front and to a certain distance from a main intrenchment, which is then called *intrenchment with lunettes.*

OF INTRENCHMENTS WITH REDANS.

52. There are two sorts of *intrenchments with redans:* namely, intrenchments with redans and *straight curtains,* and intrenchments with redans and *broken curtains:* the former are traced as follows:

On a line A B, pl. 9, fig. 39, representing the front line of the intrenchment, set off successively 120 toises, as from *a* to *b*, &c. for the length of each particular front, to the extremity of which erect a perpendicular, as *a c*, equal to 22 toises: this perpendicular will be the capital of the redan; then lay off 15 toises from *a* to *d*, and from *a* to *e* for the gorge: lastly, draw the faces *c d*, *c e*, and the line *d f*, which joins the ends of the faces of two collateral redans, will be the *straight curtain.*

53. These intrenchments were much used formerly, and even in the time of Vauban, who constructed many;* however, if we examine the figure and remember what has been said in the note *, No. 2, namely, that in general the soldier fires in a direction perpendicular to the crest of the para-

* It is generally believed that he invented them.

pet behind which he stands, we shall see, 1st: that on account of the great obliquity which the faces of the redans must have with the curtain, in order that the redans may possess a sufficient interior capacity, their ditches and that of the curtain are undefended.* 2dly: that the lines of fire from the faces *c d* and *g f* of two collateral redans cross at above 30 toises in front of the middle of the curtain which joins them, and is the base, therefore, of an isosceles triangle *d h f* that has more than 30 toises in height, and is only defended by the direct fire of the curtain; 3dly: as the lines of defence are enormously long, the fire of the faces *c d* and *k l*, far from crossing on the capital *b g* of the redan *f g i* which they ought to defend, cannot reach it; besides, even supposing that it could, the nearest point would be more than 50 toises distant from the saliant *g*: thus, a considerable space *m* remains undefended in front of each redan, and secures the assailants in their approach to it;† hence let us

* They could be defended only by a very oblique and therefore ineffectual fire; besides, Clairac has rightly observed that several redans will undoubtedly be attacked at the same time; wherefore their garrisons being occupied by their own defence, will think little of their neighbours.

† Indeed, the length of the fronts *a b*, &c. can be lessened and made equal to 80 toises only, for instance, as in fig. 40, or even less; and the lines of defence being thus made shorter, the fire of the faces *c e*, *g h*, will cross on the capital *b d* of the redan *f d i* which they ought to defend; the undefended space *k* in

conclude, that this kind of intrenchments, of which the only advantage is to exceed merely by $\frac{1}{5}$ the length of the front, cannot be effectually defended by small arms, but requires a numerous artillery.

In order to remedy these defects, Clairac has proposed to break the curtains, as in fig. 41, so that the vertex *b* of the angle *a b c* which is made by the two half curtains *a b* and *b c*, may be on the same line with the saliants *d* and *e;* this sort of intrenchments is called *intrenchments with redans and broken curtains.*

54. This construction is far preferable to the preceding, as it distributes the fire more equally,* shortens the lines of defence, and gives to the saliants *d e*, a defence which they have not in the other method; while it does not increase the length of the parapet more than 10 toises for each front *d e;* the redans can also be placed at 150 toises asunder, instead of 120, provided their capi-

front of the saliant *d* will also be smaller; yet it will remain sufficiently capacious to weaken the defence, let the redans be as near as they may; besides, the shortening of the fronts *a b*, &c. increases the labour, since more redans are required for intrenching the same extent of ground, and finally the ditches are not more effectually defended.

* The quantity of fire which a work can afford, is always proportionate to the extent of the parapet, and should be distributed equally or in proportion as the several parts of a fortification may want it.

tals are made equal to $\frac{1}{5}$ of that front, and each demi-gorge to 16 toises, as is shewn by fig. 42.

55. I shall remark, however, that the length of the front being supposed 120 toises, fig. 41, the angle formed by each face *a d* and its half curtain *a b* is still 98° 14′; and that it is 99° 54′ when the front is 150 toises as in fig. 42; hence, the defence of the ditch and ground in front of the counterscarp is very oblique, and particularly towards the salients; therefore, it is proper, I think, to break the curtains as in fig. 43, pl. 10, so that each face *a b* may make an angle of 90° with its half curtain *a c*; the ditch and ground in front of the counterscarp will thus be defended by a direct fire parallel to the faces and half curtains: this construction, I own, somewhat increases the labour and gives a direction to the half curtains, which exposes them a little more to be enfiladed; but, the disposition of the ground will sometimes allow the engineer to place on higher points the vertex *c* of the angle *a b c* which is formed by the half curtains, and when it will not, the parapet can be made higher at *c* and then sloped away along *c a* and *c d*; besides, as intrenchments have no great relief, in general, they all have the defect of presenting branches which are liable, more or less, to be enfiladed.

OF INTRENCHMENTS WITH TENAILLES, OR QUEUES D'HIRONDE.

56. To trace an intrenchment with tenailles, or queues d'hironde, pl. 10, fig. 44: upon the front line A B, of the intrenchment, set off successively 100 toises, as from *a* to *b*, for the length of each particular front, and erect in the middle a perpendicular *c d* equal to $\frac{1}{3}$ of that length; that is to 33 toises and 2 feet; join the extremity *c* of this perpendicular and those *a* and *b* of the front.

57. This is Clairac's construction, and I shall observe that intrenchments of this kind are only defended by the fire of the long branches *a c* and *c b* which the assailants can easily enfilade: besides the angle *c b e* of the tenaille is very open, whence the ditch and a considerable space *f* in front of the saliants are not defended; this defect can be remedied by shortening the fronts as in fig. 46, where the length of *a b* is only 50 toises, and allowing to the perpendicular *c d* more than $\frac{1}{3}$ of *a b* without exceeding $\frac{1}{2}$; as the angle *c b e* of the tenaille which is 90°, when *c d* is half of *a b*, would then be acute, contrary to Max. 4; it is shewn by the lines of fire, that the ditch and ground in front of the saliants *c*, *e*, are much better defended than in fig. 44; but on the other hand, the dead angles are more numerous and the labour is more considerable.

58. Noizé de St. Paul allows 120 toises to the front *a b*, fig. 45, and 22 toises only to the perpendicular *c d;* this construction is worse than any, and the author is perfectly right in saying that intrenchments with tenailles are the worst of all, if he supposes them traced according to his method; for, on account of the immense opening of the angle *c b e* of the tenaille, the ditch and ground *f* in front of the saliants are still less effectually defended than in Clairac's construction.

OF INTRENCHMENTS WITH CREMAILLERES.

59. The following is the method which Clairac proposed, and most authors recommend for tracing an intrenchment with cremaillères, pl. 11, fig. 47; upon the front line A B of the intrenchment set off successively 60 toises, as from *a* to *b*, for the length of each particular front, and to the extremities of those fronts erect the perpendiculars *a c* and *b d*, equal to 15 toises: from the upper end of each perpendicular draw a line *c b*, to the foot of the next, and on this line set off 5 toises,* as from *b* to *e:* then draw *d e*, which will be the small side

* The object of these 5 toises is to allow a greater opening to the angle *c c d*, which is formed by the crochet *d c*, and the branch

or *crochet* of the cremaillère, and *c e* will be the long side or *branch;* with regard to the proper direction of the cremaillères, it ought to be regulated by the ground.

60. Intrenchments with cremaillères afford several advantages: 1st, their saliants are little projecting; and therefore their branches are less exposed to be enfiladed; 2dly, each branch is defended, as *c e*, not only by the crochet *d e*, which is contiguous to it, but partly by the next *f g*, the fire of which is parallel to and reinforces that of *d e;* lastly, their tracing is easily adapted to the ground, and their fire equally distributed: however, they are not without defects; for, on account of the shortness of the crochets *d e*, &c. their ditch is not seen from the branch which flanks it, except at a small distance from the saliant *d*, and particularly if the relief of the intrenchment and thickness of the parapet are somewhat considerable; the little projection of the saliants *c*, *d*, &c. makes it more difficult, indeed, to the assailants, to enfilade the branches *c e*, *d f*, &c.; but, on the other hand, as their prolongations are directed on the same side, one battery can enfilade several of them at once.

61. I propose, as an improvement of Clairac's construction, to reduce the length of the fronts *a b*, *b e*, &c., fig. 48, to 50 toises,* and to make the

* Clairac admits that, according to circumstances, the length of the branches may be reduced even to 30 toises, provided the

crochets *b c*, &c. perpendicular to the branches *b d* &c. which they flank ;* by this alteration, the ditch and ground in front will be defended by a direct fire, and the lines of defence being shorter, each branch will be entirely protected, as *b d*, by the fire of two crochets *b c* and *e f*.

62. Noizé de St. Paul recommends that the branches of the cremaillères do not exceed 60 or 80 toises in length ; in order, says he, that the fire of the crochets may defend the ditch and the edge of the counterscarp of the opposite saliants; thus he approves of the branches having a length of 80 toises; but it is evident that such an immense length weakens considerably the intrenchment, since each branch is defended only by the fire of one crochet; this engineer asserts also that no smaller length than 7 or 8 toises can properly be allowed to the crochets, and I am far from opposing his opinion ; for, on the contrary, it seems to me that crochets of 7 or 8 toises are considerably too short, especially when the length of the branches is such as not to allow them to be defended by more than one crochet ; their fire is too weak, and should the intrenchment have a certain relief and

crochets are perpendicular to them, and have a length of 12 toises at least.

* According to Clairac's method, the angle formed by the crochets, and the branch which they flank is 95° 21′.

the parapet a certain thickness, no part of the ditch of the crochet could be seen, except, perhaps, that near to the saliant; strictly speaking, a single flank of 7 toises in length may suffice for a small field fort, but it is too short for an intrenchment of armies, the object of which, in general, is more important, and requires that the flanking parts should have a greater extent; therefore, my opinion is, that so small a length should never be given to the crochets, unless a few cremaillères only are requisite for fortifying a point of no great importance, and which does not require to be strongly defended.

63. Several methods have been proposed for reinforcing intrenchments with cremaillères; the following is recommended by Clairac: he divides the whole front A B of the intrenchment into particular fronts *i w* of 400 toises each, fig. 49, and upon their middle he constructs a saliant *a b c*, whose branches *a b*, *b c*, are equal to those *g f* of the cremaillères, which he traces, as well as the crochets *a f*, &c., conformably to his usual method, which I have explained in No. 59; this saliant is flanked on both sides by the two crochets *a f* and *c d*, which, therefore, have a contrary direction, as the figure shews: at the extremities of each particular front *i w*, he constructs a bastion, the capital *h i* of which is at a distance of 20 toises from the point *k*, where the prolongation of the last

branch $l\,n$ meets the line A B; and the last crochet $m\,n$, which is traced like the others and has the same length, is the flank of the bastion: the capital $h\,i$ is equal to 35 toises, and the face $i\,m$ is drawn from its extremity to that of the flank.

64. The advantages which Clairac expects from this construction consist, first, in obtaining the same quantity of musketry fire from the flanks $m\,n$, &c. of the bastions, as from the crochets of the cremaillères; and, secondly, in procuring a first defence to the intrenchment, by means of the artillery which he places on the faces $i\,m$, $w\,x$, and whose fire crosses in its front; he asserts likewise, that the fire of the four crochets nearest to the saliant $a\,b\,c$, two on the right, and two on the left, will cross in front of this saliant, which being the most distant point from the bastions, and consequently from the artillery, is particularly in need of that fire; that the two former advantages result from Clairac's construction is undeniable, but as for the latter, it cannot procure it, unless the length of the fronts $a\,g$ and $c\,q$ is 50 toises at most; for, if we suppose it to be 60 toises, as the author recommends, the considerable extent of the line of defence will prevent the fire of the crochets $g\,l$ and $q\,r$, crossing properly in front of the saliant $a\,b\,c$, Max. 5.*

* Clairac has supposed, in all his constructions, that the range of a musket is 120 toises; but no reliance should be placed on

Besides, it is to be observed that the fire of the branches *a r* and *b t*, which are the nearest to the bastion, cuts its capital at a great distance from the flanked angle, which is the most exposed point, and thus becomes the weakest; for a considerable space of ground *u*, in its front, remains undefended; moreover, the ditch of the faces is not seen, and part of the ground facing them is protected only by their own fire: add to this that the small opening of the flanked angle exposes the faces to be more easily enfiladed; therefore it appears to me, that Clairac's supposed improvements weaken the intrenchment which they are intended to strengthen, unless the flanked angles can be secured from the enemy's attacks.

65. Fig. 50 represents a scheme for reinforcing an intrenchment with cremaillères, which Noizé de St. Paul proposes in his work; he applies it, like Clairac, to a front, *c q*, of 400 toises; this construction is better than the preceding, especially if it is Noizé de St. Paul's intention, which he does not explain, that the last crochet *a b*, should be perpendicular to the line of defence *a c* of the bastion, the flank *m o*, to the line of defence *o b* drawn from the extremity *b* of the last crochet to the angle *o* of the flank, and the other crochets *d e*,

the fire of small arms at such a distance, although a musket may carry its shot even farther.

&c., to the branches *d b*, &c., which they flank; for, the fire of the two crochets *a b* and *k l*, will then cross on the capital of the bastion, close to the flanked angle, after grazing the faces, whose ditch will also be defended by it; the fire of the face, that of the two crochets *a b*, *d e*, and of the curtain *a o*, will cross likewise in front of the face. Nay, the distance of the crochet *d e* from the flanked angle of the bastion is not so considerable as to render its fire quite useless for the defence of the capital; I shall observe, however, that a considerable space of ground *n* in front of the central branches *g h*, *i h*, is defended merely by their direct fire and that of the artillery of the bastions; and as Noizé de St. Paul allows a length of 25 toises only to the capitals of the bastions whose gorges he makes equal to 50, it follows that the artillery of the flanks that are very short, affords little protection to the front *c q*, which they defend, and particularly towards the re-entering angle *g h i*, since, on account of their small projection beyond the cremaillères,* scarcely one gun, placed near the angle of the shoulder, can graze the front; I shall also remark, that the direction which the great opening of the flanked angle gives to the faces requires that the fire of their artillery

* In order that the flanks of the bastions may have a certain projection beyond the cremaillères, the crochets should be very small, which, as I have observed, is defective.

should be very oblique, in order not to pass at a considerable distance from the re-entering angle *g h i;* I now propose to rectify Noizé de St. Paul's method in the following manner:

66. Make the distance *k s*, between the capitals of the bastions, pl. 12, fig. 51, equal to 400 toises, and the fronts *al*, *lc*, &c. to 50: allow 15 toises for the length of the perpendiculars *l m*, *c f*, *d o*, and make the crochets *c g*, *d p*, perpendicular to the branches *c h* and *d g*, which they flank; set off 25 toises from *a* to *i*, for the demi-gorge of the bastion, and 30 toises from *a* to *k*, for the length of its capital: draw the line of defence *k l* to the foot of the last perpendicular *l m*, and make the last crochet *l h*, perpendicular to that line: then draw *h i* from *h*, to the extremity *i* of the demi-gorge, and *i n* perpendicular to *h i;* produce it till it meets the line of defence *k l*, at *n:* thus will *i n* be the flank of the bastion, and *k n* the face.* It

* Nay, I do not see any good reasons why you should not break the small curtain *i l*, which only defends itself when it is straight; whilst, on the contrary, the two half curtains *i q* and *q l*, will carry their fire towards the capital of the bastion, and in front of the saliant *h*, of the cremaillère *l h c*, after grazing the crochet *l h;* the curtain will not be endangered by this disposition, for it is defended by the face *k n* of the bastion, and placed in a re-entering part under the protection of the flank *i n*, and the two crochets *l h*, *c g*, the fire of which crosses in its front: the smallness of the curtain may be objected to: but I shall observe that the length of the half curtain *q l*, which is the smallest,

may easily be seen that by this construction, a greater length is allowed to the flanks of the bastions; whence several guns can be placed near the shoulder, which, without any danger to the cremaillères, and after battering the assailants in their approach, can graze the intrenchment closely, and pour grape shot upon them when they are near to it: thus the ground in front of the re-entering angle *p e r*, is well defended; besides, owing to the direction of the faces of the bastions, the fire of their artillery will pass at no great distance from the intrenchment, without being so oblique as in Noizé de St. Paul's method, and all these advantages are gained with but little additional labour; I own that the faces of the bastions are a little more exposed to be enfiladed, since the flanked angle is less open, but this defect can be remedied, as I have explained, No. 55; besides the effect of the bastions, with regard to the defence of the intrenchment, ought not to be sacrificed on that account, as it would then be better not to construct any.

67. Noizé de St. Paul recommends another method, fig. 52, which resembles very much that of

is not very different from that of the crochet *l h*; and if am told that the bottom of its ditch cannot be well discovered from *l h*, I answer, that little would be lost by it, since the ditch of a straight curtain, in the case before us, could be defended only by a very oblique and therefore ineffectual fire.

Clairac, fig. 49, and is still worse, as it has most of its defects, and in a higher degree; for instance, it is evident that on account of the small curtain *a b*, the fire of the branch *b c* cuts the capital of the bastion still farther from the flanked angle; it would be less defective to omit the small curtain *a b*, and draw the branch *b c*, to the angle of the flank, as is shewn by the dotted line *a c*, the flank being perpendicular to it; with regard to the bastions, they have the same defects as those in fig. 50, since Noizé de St. Paul allows them the same dimensions, and therefore, what I have said of the latter, may be applied to the former; lastly, this engineer would have perceived what little effect can be expected from the artillery fire of the saliant angle *d e f* for the defence of the capitals of the bastions, had he considered the great obliquity which this fire must have to cut them, even at a considerable distance from the flanked angle which, within that distance, has no flanking defence whatever.

The scheme represented by fig. 53, and which Noizé de St. Paul applies to a front *i k*, of 600 toises, may be made better than the preceding; but to that purpose, the bastions *i*, *k*, of the extremities of the front, should be constructed according to the directions which I have given in No. 66, and for the same reasons: the curtains *e g* and *l m* should also be broken, and the flanks of the central bastion *n*, whose gorge and capital I make equal

to those of the bastions *i*, and *k*, should, as well as the crochets, be perpendicular to the branches by which they are respectively flanked; without which the central bastion would have the same defects as those *i* and *w*, in Clairac's method, fig. 49: that is, the fire of the branches *a b* and *c d* would cut its capital at a very great distance from the flanked angle; but, as in the method which I propose, the angles formed by the flanks of the bastion, and the branches which flank it are 90°, instead of 95° 21′, which they have in Clairac's construction, it is evident that the capital will be cut nearer to the flanked angle; however, there will still remain a considerable space of ground in front of this angle, which receives no flank defence, except from the artillery fire of the collateral bastions *i* and *k*, which stand at a distance from it.

68. Noizé de St. Paul proposes also to reinforce intrenchments with cremaillères, by means of *queues d'hironde*, *i d p c q*, pl. 13, fig. 54; according to this method, the distance *o d*, between the *queues d'hironde*, is 320 toises, and 40 toises are allowed to the perpendicular *a d*; the author does not fix any particular length for the crochets; nor does he explain the angle which they make with their respective branches: but it is evident, that after his construction, this angle should be obtuse,* even should the length of the crochets be

* I beg the reader will remember what I have said on No. 61,

15 toises: for were it a right angle, the face *i d* of the *queues d'hironde* would be exposed to the fire of the crochet *e f*, as is shewn by the dotted line of fire *m n*, since the distance between them, which is greater, I own, than the proper length of the line of defence, does not exceed the range of a musket;* besides, the saliant, *d*, would thus be deprived of part of the protection, which, strictly speaking, it may receive from the crochet *e f*. In consequence of these observations, I propose the following construction:

On the front line of the intrenchment set off successively 320 toises, as from *n* to *a*, pl. 13, fig. 55, and erect at *n* and *a*, the indefinite perpendiculars *n o* and *a b*: lay off 60 toises from *n* to *s*, and from *a* to *g*, and divide *s g* into four equal parts, each 50 toises: make the crochets perpendicular to their branches, and produce the branch *c e*, till it meets the perpendicular *a b*, the length of which will be determined by its intersection with *c e* produced.† From *b* draw the line of de-

respecting the advantage which arises from the crochets being perpendicular to the branches.

* Noizé de St. Paul himself says in page 197 of his work, note *a*, that although the common range of a musket should not be supposed more than 100 toises, in order that the effect of the fire may be relied upon, still a man can be struck by a ball from a distance of 150 toises.

† By this construction, the crochets are perpendicular to their branches, without the face *b l* being exposed to the fire of the

fence *b g*, and make the crochet *e g*, perpendicular to it: next, set off 10 toises from *a* to *l*, and through *e* and *l* draw *e v*, indefinitely produced: then, direct the face *b l* to *e v*, and in such a manner that it will form with *a h* an angle not less than 15°, and with *e v* an angle exceeding as little as possible 90° (vide Max. 1 and 4):* lastly, break the curtain as the figure shews, and after making *a f* and *f i* equal to *a b*, draw the diagonals *i a* and *b f*, whose intersection *h* will be the vertex of the re-entering right angle *b h i*.

69. With regard to the *queues d'hironde o* and *r*, make *n o* equal to *a b*, and set off 10 toises from *n* to *p*; then through the extremity *t* of the perpendicular *s t*, and through the point *p*, draw *t w* indefinitely produced: make the crochet *s q* perpendicular to *t w*, and direct the face *o p* conformably to the directions given respecting the face *b l*.

OF INTRENCHMENTS WITH BASTIONS.

70. To construct an intrenchment with bastions, pl. 13, fig 56, on the front line A B set off• suc-

crochet *e d*, and the saliant *b* deprived of the protection, which, strictly speaking, it may receive from it, as I have stated.

* The angles *m l b* and *l b h* vary according to the length of the perpendicular *a b*; therefore care must be taken that they have a proper opening in all cases.

cessively 100 toises, as from *a* to *b*, which will be the distance between the flanked angles, and bisect this distance by the perpendicular *c d* equal to $\frac{1}{6}$ of *a b*; through the extremity *d*, of this perpendicular, and the points *a* and *b*, draw the lines of defence *a f* and *b e*: then, make the faces *a g* and *b h*, equal to half the distance from the flanked angles *a* and *b*, to the angle *d* of the tenaille, and describe the flanks by letting fall from *g* and *h* the perpendiculars *g e* and *h f* to the lines of defence: lastly, break the curtain, and direct its halves *e d* and *f d*, to the intersection *d* of the lines of defence.

71. An intrenchment with bastions is capable of making a very strong defence, and the assailants cannot approach it without being exposed to the effect of the cross-fire which covers all the ground in front. Such an intrenchment, however, is not without defects; for, as the counterscarp runs parallel every where to the principal line,* it follows that the ditch in front of a face, of the face *a g*, for

* In permanent fortification, the countercarp of the ditch, in front of the faces of a bastion, is directed to the shoulder angle of the next, so that the ditch is entirely seen from the opposite flank which defends it; but this cannot take place in the case before us, as it would require considerable labour, which can scarcely be effected in the field: besides a great and useless quantity of earth should be removed, which would occasion material inconveniences.

instance, is masked by it, and cannot be seen from the flank *h f*, which ought to defend it; in order to rectify this defect, cut away the ground *i* sloping towards the ditch,* and in the direction of a visual ray *m n*, which being drawn from the interior crest of the parapet of the flank *f h*, terminates at the bottom of the ditch, in a point *n* opposite the shoulder angle, or passes at three feet at most above that point. Should it happen, that on account of the great depth of the ditch, or small relief of the work, the visual rays drawn from the opposite flanks *f h* and *e g*, meet the ground between them and the perpendicular *c d*, join the points where they meet it, by a sort of advanced ditch, which, as it is seen from the flanks *f h* and *e g*, will not prejudice the defence.

72. Noizé de St. Paul allows only $\frac{1}{8}$ of *a b*, to the perpendicular *c d*, fig. 57, and this construction has two advantages over mine, fig. 56: namely, the sector *e b f*, which cannot be defended by the fire of the faces of the bastions, is somewhat smaller than in my method; and besides, as the flanked angle *b* is more open, the faces are a little less exposed to be enfiladed; but those advantages are dearly purchased: 1st, because the extent of the sector *e b f*, is still sufficient to enable a column to

* A sort of ramp is thus formed whose breadth must be equal to that of the ditch, which, without it, could not be entirely seen from the opposite flank.

advance in the direction of the capital, and approach the flanked angle, without having any thing to fear from the fire of the faces; whence, this angle is not less in need of the protection of the flanks, from which it receives, on the contrary, its principal defence. 2dly. Because a considerable part of the fire of the flanks which are very short in Noizé de St Paul's construction, should be applied to the defence of the ditch, had it a certain breadth; and therefore, the counterscarp and ground in front would be feebly protected; indeed this engineer asserts that the defects arising from the shortness of the flanks will be remedied by breaking the curtain; but he has not observed, that by the disposition of his tracing, the musketry fire of the half curtain cuts the capital at a distance too great to have any effect.

73. It is most proper, undoubtedly, that all parts of a fortification should be exposed as little as possible to be enfiladed, and precautions to that purpose must be taken with regard to the faces of the bastions, as they afford a first defence to the intrenchment; but this defence is not sufficient in general to secure it; and besides, the flanked angle, as I have observed, stands much in need of the protection of the flanks, whose fire is the only one which passes close to it; therefore, if on account of their shortness, their fire is not sufficiently

effective, not only the flanked angle will be weakened, but also the whole system of defence; and the advantage of the faces being less exposed to enfilade, will be overbalanced by the inconveniences arising from it.*

74. In Clairac's method, pl. 14, fig. 58, the distance *a b* between the flanked angles of the bastions is 120 toises, and $\frac{1}{5}$ of *a b* is allowed for the length of the perpendicular *c d:* the faces *a e* and *b f* are equal to $\frac{1}{2}$ of *a d*, and the flanks *e h* and *f g*, perpendicular to the lines of defence; lastly, the curtain is broken, and each half curtain *h d* and *g d*, terminated at the intersection *d*, of the lines of defence. By this construction, the flanks are still longer than by my own, and the fire of the half curtains cuts the capital somewhat nearer to the flanked angle; but the faces are more exposed to be enfiladed, as the flanked angle is less open, and this defect is not compensated by any material advantage; on the other hand the length of the lines of defence is great, and the execution of the mus-

* I have asserted myself, in the note relative to Max. 1, that the more acute a saliant is, the easier it is for the enemy to enfilade its sides, since he can take their prolongation with greater facility: but let us not conclude from thence, that in order the better to secure the faces of the bastions from enfilade, other considerations of no less importance should be sacrificed; since, on the contrary, field-works cannot afford any good defence, unless all their parts are well combined.

ketry fire of the flanks can scarcely be relied upon, for the defence of the flanked angle.

OF INTRENCHMENTS WITH LUNETTES.

75. Lunettes were originally contrived to reinforce intrenchments with redans and straight curtains, which were then most commonly used; it is evident, however, that lunettes should not be adapted to such intrenchments, as they can be flanked only by the faces of the redans, the fire of which, if they are constructed according to the usual method, enfilades the gorges of the lunettes, or is directed to their faces; and if, in order to avoid this defect, a sufficient obliquity is allowed to the faces of the redans, then the curtains and the redans themselves are undefended by any flank fire. Clairac, who was aware of these inconveniencies, has proposed the two following methods of tracing intrenchments with lunettes:

First, on the front line A B of the intrenchment, fig. 59, he sets off successively 120 toises, as from *a* to *b*, for the length of each particular front, which he bisects by a perpendicular *c d* equal to 35 toises, and through the extremity *d* of this perpendicular, and those *a* and *b* of the front, the branches *a d* and *b d* are drawn: next, he carries 25 toises from *d* to *e* for the length of the capital

of the redan, and 18 toises from *d* to *f* and *g*, for the demi-gorges: he draws the faces *e g* and *e f*, and sets off 60 toises from *c* to *h*, on the perpendicular *c d* produced, for the distance of the saliant *h* of the lunette, from the front *a b*: Lastly, through *h*, and in the direction of the points *l* and *m*, taken at 20 toises from those *a* and *b*, he draws the faces *h i* and *h k* of the lunette, which he makes equal to 25 toises, and are flanked by *a l* and *b m*.*

To communicate with the lunette from the intrenchment, Clairac constructs a *caponière c n*, opposite the saliant *e* of the redan, and produces it to the gorge *n* of the lunette, where its breadth is 15 feet: he makes it 30 feet broad at the other extremity *c*, on the front line *a b*; thus, the assailants can be seen from a front double their own, and more, supposing that they will enter the caponière through its extremity *n*, after they have carried the lunette; but, as the saliant *e* of the redan faces the caponière, and cannot flank it properly, Clairac constructs a *tambour o p q r*, in the form of a glacis, to defend its approach; the branches *o t*, and *r s* are parallel to the counterscarp of the redan, and 3 toises distant from it;

* The ditch of the lunette, when it is dry, should be produced in a slope, as I have explained, No. 71, when speaking of bastions; in order that it may be seen from the intrenchment, and afford no cover to the assailants.

a traverse *v x* is also constructed opposite the caponière which it enfilades, and placed at a sufficient distance from the sides of the tambour, not to obstruct the communication with the caponière whose parapet is elevated 3 feet only above the horizontal line, that it may not impede the fire of the intrenchment; the terre-plein of the caponière is sunk 16 inches, and when the country is level, its parapet has no superior slope; but when it is not, the top of the parapet is made sloping, so that the country may be grazed by the fire of the caponière.

As a banquette would require the breadth of the caponière to be greater, and expose the troops which defend it to the reverse fire of the assailants, none is allowed to it; besides, should there be any banquette, the terre-plein should be sunk to a greater depth,* and the assailants, after entering the caponière, would be less exposed to the plunging fire of the intrenchment.

In order to prevent two neighbouring caponières annoying each other by their fire, Clairac places lunettes on every other front only, when they are in the same line; and he proposes in this case, to shorten by some toises the length of the intermediate front which is then better defended by the fire of the caponières.

* This additional depth should be equal to the height of the banquette.

76. This construction of Clairac has a great defect; namely, the fire of the parts *l g* and *m f* of the intrenchment is at a stand, as long as the troops defend the lunette, as it would annoy them; and in order to remedy it, the author proposes the following method, fig. 60, which he says increases the labour, but directs two additional columns of fire towards the saliants *a* and *b:*

Trace the same figure as in the preceding construction, fig. 59, excepting the redan *g e f*, and set off 45 toises from *a* to *c* and from *b* to *d:* then draw the lines of defence *a d* and *b c*, indefinitely produced, and after making *a f* and *b e* equal to 20 toises, let fall from *f* and *e* the perpendiculars *f h* and *e g* to the lines of defence: *a f h c i*, &c. will be the outline.* The lunette, caponière, tambour, and traverse are constructed in the same manner as in the other method, with this difference however: namely, the caponière is longer, and the branches of the tambour are directed as the figure shews.

* Clairac proposes also to apply this construction to an intrenchment without lunettes; but it may be seen by the figure that such an intrenchment is little more than an intrenchment with bastions, whose curtains are partly broken inside, instead of outside conformably to the usual method; now, I do not conceive what advantages can arise from the curtains being thus broken: for, if on the one side, the direction of the fire from *m n*, for instance, is nearer to the saliant *b*, on the other hand the lines of defence are considerably longer, and therefore the capital is not better defended.

Lunettes may also be placed in front of an intrenchment with tenailles, or an intrenchment with bastions: but as those works receive their principal defence from the intrenchment, it is requisite that the direction of their faces should be as perpendicular as possible to the parts which flank them: and besides, the distance from their saliants to those parts, should not exceed the proper length of the lines of defence, Max. 5.

77. It is undeniable that lunettes properly constructed and disposed, may answer, in some cases, a very useful purpose, No. 3; I observe, however, 1st, that the requisite direction of their faces sometimes occasions difficulties in the tracing: 2dly, their construction and that of the caponières require considerable time and labour: 3dly, if the lunettes are near to the intrenchment, they may partly obstruct its fire, unless it has great relief: and should they be placed at a distance from it, besides the additional time and labour which the greater length of the caponières would require, the gorges of the lunettes might be exposed; therefore, an engineer ought to use those works with consideration, and he should examine whether the advantages which he expects from them overbalance their inconveniencies.

But when the ground in front of an intrenchment presents some secure points, as a morass, an inundation, &c. which, on account of their situation,

may flank the line and take the assailants in reverse should they approach it, then it is undoubtedly most important to take advantage of those points, particularly if they see some weak parts of the intrenchment, and to throw up there redans, redoubts, detached bastions, &c. or any other works so disposed as to attain the desired object.

78. I shall make this last observation concerning lunettes: that is, they should be constructed with flanks, when possible; for this disposition, which improves their particular defence, has still the advantage of affording a cross-fire over the capitals of the intrenchment and nearer to the saliants than it is when the lunettes have no flanks; should the lunettes be in the same line, care must be taken that they are at a sufficient distance asunder, not to annoy each other by the fire of their flanks, and this distance should not be less than about 200 toises; but, if they are not in the same line, they may be placed nearer.

OF LINES WITH INTERVALS.

79. The works most commonly used in constructing lines with intervals, are *redans, redoubts, queues d'hironde*, and *bastions;* but, the irregularity of the ground and other circumstances may require other works of different forms, to which

no particular names can be given, as their figures may vary without end.

80. Whatever the works may be which compose a line with intervals, they should defend the ground between them and protect each other;* wherefore the length of the lines of defence, and more particularly the breadth of the intervals, should not much exceed 80 toises, Max. 5: the flanking parts should also be perpendicular to the lines of defence; or at least, they should deviate as little as possible from that direction, Max. 4: lastly, the works should be thrown up on the most saliant points of the ground and the intervals be placed in the re-entering parts, as the access to them will thus be more difficult to the assailants.

81. After these preliminary rules, it is obvious that a line with intervals composed of a single row of redans, like fig. 63, pl. 14, or of redoubts, as fig. 63, pl. 15, is weak by its nature; for, the musketry fire of those works crosses at a distance in front of the intervals and feebly defends the saliant, as I have observed in No. 53, when speaking of continued lines; hence we may conclude that such line cannot afford any great resistance,

* Care should also be taken that the works do not fire upon each other, like the redans, pl. 14, fig. 61, and the redoubts, fig. 62.

unless it receives an additional strength from troops or cannon placed opposite to the intervals.

In fig. 63, pl. 14, the redans are placed at 100 toises asunder, the length of the capital *a b* is 22 toises, and that of the demi-gorge *a c* 15 toises. In fig. 63, pl. 15, I have allowed 15 toises for the length of the interior side *a b* of the redoubts, and no much smaller allowance can properly be made, as the redoubts would then be two weak.

If redans with flanks are constructed, (vide the upper row of redans in fig. 66, p. 15,) the intervals and saliants will be better defended, and therefore the line will be stronger; I place these redans at the same distance asunder *f c*, as those in fig. 63, pl. 14. I allow 22 toises likewise to the capital *f g*, but I increase by 2 toises the gorge *a e** in order that the flanks *b d* and *v u* may have a certain length, without shortening beyond measure the faces *f d* and *f u*, and diminishing the interior capacity of the redan; to trace the flanks, I set off 4 toises on the gorge from *a* to *b*; and from the extremity *c* of the capital of the next redan, I draw the line of defence *c b* to the point *b*; then I make *b d* perpendicular to *c b*.

* I increase the length of the gorge *a c* only 2 toises, in order that the fire of the faces of the redans may cross nearer to the intervals and pass at a smaller distance from the two opposite saliants.

82. When a line with intervals is composed of a double row of works, as in fig. 64, 65, and 66, its strength is generally greater, since the works of the second row flank those of the first; besides, the assailants have a double obstacle to overcome, before they can carry the intrenchment; this sort of lines, however, is not without defects; for, it augments the labour considerably, and a line with intervals is often constructed, for the purpose of saving both time and labour; moreover, a greater number of men is requisite for the defence of the works, which weakens the reserves, and may impede the intrenched army in making opportunely such offensive movements as would prove of great effect; lastly, the works of the second row may sometimes obstruct the movements of the troops, and supposing they will not, their own fire may be obstructed by them; therefore, these lines should be used with consideration, and in such peculiar circumstances only, as will remove the defects which they have in general.

To trace the redans of the second row, fig. 64, carry 70 toises from *a* to *e*, and from *b* to *g* in the prolongation of the faces *a d* and *b k* of two adjacent redans in the first row; then through *e* and *g*, draw *f h* and *h i* perpendicular to *a e* and *b g*, and these perpendiculars, which should be equalto *a d*, are the faces of the redan, whose saliant *h* is determined by their intersection.

In fig. 65, trace the second row of redoubts by setting off $71\frac{3}{7}$ toises from *a* to *b*, and from *c* to *b*, in the prolongation of the sides *a d* and *c h* of two adjacent redoubts in the first row; next, carry from *b* to *e*, and from *b* to *g*, the length allowed to the interior sides of the redoubts; and lastly, erect the perpendiculars *e f* and *g f* to *b e* and *b g*.

With regard to the redans of the second row in fig. 66, set off 70 toises from *f* to *h*, and from *c* to *k*, in the prolongation of the faces *f d* and *c p;* then through *h* and *k* draw *w m* and *n m*, perpendicular to *f h* and *c k:* and the point of meeting *m* of these perpendiculars, which should be equal to *f a*, will be the saliant of the redan; to trace the flanks, join *w n*, and set off 8 toises from *n* to *o;* then draw the line of defence *i o*, and make the flank *o s* perpendicular to it.

83. We find in Noizé de St. Paul's work, the two constructions represented by fig. 67 and 68; the author does not explain the length which he gives to the faces *a b* and *c d* of the redans, and to the sides *e f* and *g h* of the redoubts; but, according to his scale, *a b* and *c d* are 20 toises, and *e f* and *g h* 15 toises: the angles formed by the redans are 90°, and the redoubts are square: the sides *a i* and *o i*, *e k* and *m k* are 100 toises, and, therefore, the immense length of 140 toises is allowed to the distances *a o* and *e m*, between the

saliants *a*, *o*, and *e*, *m*.* These constructions require less labour than those represented by fig. 65 and 66; but it is evident, on the other hand, that a line thus formed, is extremely weak; for the intervals are very feebly defended, as may be seen from the figures, and the large spaces *u*, which no part of the works protect, favour all movements which the assailants may make, either for turning the redans and redoubts of the first row, or advancing in the direction of the capitals of those of the second; besides, the saliants of the works of the first row, and particularly those of the redans, are feebly defended by the works of the second, on account of the shortness of the flanks that protect them, and of the length of the lines of defence, which are 90 toises in fig. 67,† and 85 toises in fig. 68.

84. A line with intervals may also be composed of *queues d'hironde*, pl. 16, fig. 69 and 70; and of *bastions*, fig. 71 and 72.

To trace the queues d'hironde, fig. 69, set off 90 toises from *a* to *d*, and erect the perpendiculars *a b* and *d c;* make these perpendiculars equal to 30 toises, as well as *a e* and the perpendi-

* This is evident, although Noizé de St. Paul does not explain it; since *a o* and *e m* are the diagonals of the squares, of which *a i* and *o i*, *c k* and *m k* are the sides.

† Noizé de St. Paul makes *i e* equal to 10 toises.

cular *e f:* next, draw the diagonals *a f* and *e b*, whose intersection *g* is the vertex of the re-entering angle *f g b*, which is consequently a right angle: lastly, carry 10 toises from *a* to *h;* and from the extremity *t*, of the perpendicular *d c*, draw the line of defence *c h*, to which the face *b i*, of the queue d'hironde, must be perpendicular.

For the queues d'hironde, fig. 70, carry 90 toises from *a* to *d*, and from *d* to *k*, and erect at *a*, *d*, and *k*, the perpendiculars *a b*, *d c*, and *k m*, of 30 toises: next, set off 35 toises from *a* to *e*, and from *d* to *f*, and draw the lines *b e* and *c f*, to which erect the perpendiculars *e g* and *f g*, meeting each other in the point *g:* lastly, set off 10 toises from *d* to *h*, and after drawing the line of defence *m h*, make *c i* perpendicular to it.

85. To trace the bastions, fig. 71, set off 100 toises from *a* to *b*, and erect the perpendiculars *a c* and *b d*, for the capitals, which should be equal to 25 toises; then carry the same length from *a* to *e* and *f*, for the demi-gorges: lastly, draw the line of defence *d e*, perpendicular to which make the flank *e g* whose length is determined by its meeting with the line of defence *c h*.

86. Noizé de St. Paul places the capitals *a c* and *b d*, of the bastions, fig. 72, at 110 toises asunder: he only allows 20 toises to the capital *a c*, and makes the demi-gorges *a e* and *a f*, equal to 31

toises each, or thereabout: this disposition is not so strong as that which I propose: since the flanks *g e* and *h i* are much smaller; besides, the fire of the faces *c g* and *d h* crosses at a greater distance from the intervals, than in my method.

87. Clairac recommends the construction represented by fig. 73, and I shall not attempt to describe the tracing of it, as it is sufficiently explained by the dimensions which I have annexed to the figure; I shall only observe that in this method, the lines of defence *a b* and *c d*, are very long, and that the flanking angles exceed 90°.

88. In the analysis which I have made of several methods proposed by Clairac and Noizé de St. Paul, with regard to intrenchments of armies and other subjects, it has not been my object to use criticism, in order to promote my own opinion; nor to lay claim to any superiority over those two distinguished engineers; but Clairac, who much enlarged the limits by which field-fortification was circumscribed in his time, has still a celebrity which may induce many military characters to adopt indiscriminately all his ideas; and his work, which has been translated into English by Muller, is much sought for. With regard to Noizé de St. Paul, he undoubtedly is the modern author who has treated of field-fortification with the greatest success; either by explaining the improvements which have taken place in that branch of science,

since Clairac's time, or by proposing observations and methods of his own, several of which deserve approbation; and his work, which is generally thought most valuable, is also in great circulation. I shall conclude with asserting, that whenever I discussed the opinions of Clairac, Noizé de St. Paul, Bousmard, Tielke, and others, I was only actuated by the desire of fulfilling a task useful and agreeable to the military world; and I leave it to experienced officers to decide whether the remarks which I have made, and may make hereafter, are correct.

END OF THE FIRST PART.

PART THE SECOND.

CHAPTER IV.

Of the Height of the PARAPET *of* FIELD-WORKS; *of its Thickness; of its* INTERIOR, EXTERIOR, *and* SUPERIOR SLOPES; *of the* BERM, *and of the* SLOPE *of the* COUNTERSCARP; *of the Breadth and Depth of the* DITCH; *of the* BANQUETTE *and its Slope; of the several Methods used in constructing the* REVETEMENT; *of* PALISADES, FRAISES, *and* PALISADES-CAPONIERES; *of* ABATIS, CHEVAUX DE FRISE, CROWS-FEET, HARROWS, PICKETS, *and* TROUS DE LOUP; *of* INUNDATIONS, *&c.; of* FOUGASSES; *of* SIMPLE GLACIS; *of* COVERT-WAYS *and* GLACIS; *of* AVANT-GLACIS; *of the proper Method of regulating the Slopes of* GLACIS *and* AVANT-GLACIS; *of* PASSAGES, BRIDGES, *and* GUARD-HOUSES; *of* REDOUBTS;* *further Considerations on* CREMAILLERES; *of* DEFILEMENT *and* TRAVERSES.

OF THE HEIGHT OF THE PARAPET.

89. THE height *a o* of the parapet of field-works, pl. 18, 19, and 20, fig. 78, &c. should not always be the same; for, they are not to make an

* These redoubts are small works which sometimes are constructed inside of a larger one.

equal defence in all cases, and the nature of the attacks, which they are intended to resist, may also be different; besides, the length of time, the quantity of materials, and number of workmen of which an engineer can dispose, do not always allow him to regulate at pleasure the dimensions of their profile; field-works may be single, or preceded by out-works, which they must protect and command; they may be situated in a plain, or on a rising ground which overlooks the surrounding country; lastly, they may be commanded by hills,* and all these circumstances require some difference in the height of their parapets.

90. The rules to be followed in ascertaining the requisite height of the parapet of field-works, in the various cases that may occur, are chiefly founded on the *command* which they must have;† therefore, I shall enter into the particulars of this subject, and first suppose that the ground upon which the works are thrown up, is on a level with the surrounding country; at least, for a greater

* The particulars relative to this case shall be explained under the head *defilement*.

† The reader knows that the *command* of a work signifies the elevation of the interior crest of the parapet above the ground where the attacks may be carried; and that the height of the parapet means the elevation of that crest above the terreplein of the work.

distance than the reach of the arms which will probably be used in attacking them.*

91. It is generally known that the principal object of the parapet is to cover the troops which defend a work, and to give their fire a command over that of the assailants: now it has been proved by experience, that a man of common size can fire in a horizontal direction about 4 feet 6 inches higher than the ground upon which he stands; therefore, should the command of a work, pl. 17, fig. 74, be only 4 feet 6 inches, not only the fire of the garrison would have no superiority over that of the assailants, but theirs would plunge into the work, as is shown by the line of fire *b c*, and take in front, in flank, and in reverse the soldiers on the banquettes *e, f, d*, by availing themselves of small irregularities *a* which are found even on the levellest ground; nay, even supposing that there should be no irregularities, as the common size of a soldier is between 5 and 6 feet, a parapet less elevated than 6 feet could not cover the troops; hence we may conclude that a less command scarcely suits works which are thrown up to cover small posts, from which no resistance is required.

* It is evident that in this case, the height of the parapet of the works is the same as their command, so that the one may be taken for the other.

92. We find profiles in the works of many authors, where the height of the parapet above the surrounding country is no more than 4 feet 6 inches, and some recommend in this case to sink the terreplein *a*, as in fig. 75; but by that means part only of the defects which I have been explaining are removed, and other inconveniencies arise from it; first, the fire of the work does not command better that of the assailants, and although the terreplein *a* may be covered, yet the soldiers on the banquettes *e*, *f*, *d* are still exposed to the horizontal and plunging fire of the enemy, as may be seen from the lines of fire *b c* and *g h*; besides, the construction of the parapet requires a small quantity of earth, and as part of it is supplied from the excavation of the terreplein, it follows that the ditch, which procures the rest, has scarcely any breadth and depth; thus no particular defences, such as *palisades*, *abatis*, &c. can be placed therein; which, in addition to its small dimensions and to the trifling height of the parapet, makes the latter easy to escalade.

93. When the command of a work is 6 feet, fig. 76, its fire has a certain superiority over that of the assailants; the garrison is also covered from their horizontal and plunging fire, and the requisite dimensions of the ditch, which then supplies alone the earth wanted for the construction of the parapet, render the escalade more difficult; but the

soldiers placed on the banquettes *d*, *f*, are not secured from the reverse and enfilading fire which the enemy can make against them from a proper distance, and in a direction tangential to the interior crest of the parapet, as is shown by the line of fire *a b*; for, the height above those banquettes, at which the projectiles may pass, is smaller than the common size of a man, and, therefore, the soldiers who occupy them may be struck; besides, should the attack last for a certain time, the crest of the parapet would be damaged, the men more exposed, and even the terreplein would become uncovered; therefore, no great resistance should be expected from a work whose command is only 6 feet.

94. In proportion as the command is higher than 6 feet, the fire of the garrison takes a greater superiority over that of the assailants; the dimensions of the ditch become larger, and, therefore, the escalade is more difficult; the men are likewise better covered from the tangential fire of which I have been speaking; yet they are only tolerably well secured from it when the command is 7 feet 6 inches, as in pl. 18, fig. 77, and then the ditch has sufficient dimensions to allow the placing therein particular defences.

95. Besides it has been judiciously observed by several modern engineers, that cavalry, properly disposed, may be very useful in attacking field-

works, although it is not customary to use them for that purpose; at first sight this appears a strange idea, but after consideration, it seems to be well founded; for if we suppose, for instance, that the command of the redoubt, pl, 17, fig. 76, is only 6 feet, as a man on horseback can fire in a horizontal direction about 7 feet higher than the ground upon which his horse stands, it is certain that cavalry dispersed and moving about constantly, within a proper distance from the work, could direct to its interior a plunging fire (see the line of fire *c e*), so much more annoying to the garrison, which is confined in a small space, as it would be convergent; whilst, on the contrary, the fire of the work would be divergent and directed to men who, as they are dispersed and incessantly moving about, have little to fear from it; I believe, therefore, that no less command than 7 feet 6 inches should in general be allowed to a field-work, which is intended to make a certain resistance.*

96. I have hitherto supposed that the works were single; but should they defend any outworks, the command of the former, over the sur-

* Nay, a command of 7 feet 6 inches only suffices to cover the men from the plunging and horizontal fire of the enemy; and it has been proved by experience, that 12 feet, or thereabout, are requisite to secure them from the tangential fire of which I have been speaking.

rounding country, must be regulated according to that of the latter, since a main-work should have a superiority over the out-works which it protects. I shall enter hereafter into further particulars on this subject.

97. It now remains to explain what the maximum of the command of field-works should be, and I shall first observe, that the greater the command is, the more *fichant* the fire of the parapet becomes; and as this fire ought to pass at the smallest distance possible from the counterscarp, which it is important to defend, the inclination of the superior slope of the parapet must be augmented in proportion as the command of the work increases; this is particularly requisite with regard to works which have a flanking defence of their own, and especially when their ditch is deep, or the lines of defence are short; for without it, the bottom of the ditch, even near the saliants, might not be seen from the flanking parts, and the ditch of course would be feebly protected by them; therefore, should the command exceed certain limits, as the inclination of the superior slope of the parapet should then be very considerable, the men could not easily fire in its direction, and many shot would be lost in the air; on the other hand, the interior crest of the parapet would be weak, and much exposed to be destroyed by the enemy's shot.

98. The following, I trust, will be found a proper rule: namely, that according to circumstances, the command of field-works which have no flanking defence of their own, or whose lines of defence are very long, may be as much as 12 feet, but that in general it should not be greater: and that the other works require a less command, in proportion as the lines of defence are shorter.

99. I have hitherto supposed that the ground upon which the works were thrown up, was on a level with the surrounding country, so that their command might be taken as the measure of the requisite height of their parapet; but if we now suppose that the terreplein of a work is elevated three feet above the country, it is evident that although the height of its parapet may not be more than 6 feet, yet it will possess part of the advantages which a command of 9 feet would procure, supposing its terreplein to be on a level with the country; therefore some allowances may be made, according to circumstances, with regard to the height of the parapet of field-works, whose terreplein stands higher than the adjoining ground; I observe, however, that it should not in general be much less than 6 feet; for the defenders of the work would not be sufficiently covered, as has been explained, No. 91; and should the

terreplein be sunk, in order to secure the men, the dimensions of the ditch would then be too small, and the escalade easy.*

OF THE THICKNESS OF THE PARAPET.

100. The requisite thickness *a b* of the parapet of field-works (see pl. 18, 19, and 20, fig. 78. &c.), as well as its height, depends on various circumstances; the principal of which are the nature of the soil, the sort of attack which the works are intended to resist, according to their importance, and the defence which they should make: the probable length of time for which they are to stand, their distance from the ground where the enemy can place his cannon, in case he should use it, and the means which the troops on the defensive may have of impeding his attack, should also be considered.

* The terreplein of a field-work should not be sunk in order to allow a smaller height than 6 feet to its parapet, except in the following cases:—1st. When you are compelled to it, by want of time, materials, or workmen. 2dly. When the work to be thrown up is of little importance, and not intended for any actual defence; or supposing it is, when its resistance is to be of short duration: 3dly. And lastly, when the work being situated on a hill which commands the country, and is inaccessible to the enemy, you have to fear neither his horizontal and plunging fire, nor the escalade; a circumstance which seldom occurs.

101. When a work, pl. 18. fig. 78, is thrown up only for a few days, and as a security from the first fire of musketry, a thickness of 2 feet, or thereabout, is sufficient; but should it stand for a certain time, the thickness of the parapet requires 3 feet, as in fig. 79, and particularly if the soil be bad.*

If we now suppose that the garrison of a work, calculated to resist only musket shot, is to make some defence, 3 feet are requisite for the thickness of the parapet, and even 4 feet, as in fig. 80, if the soil is not good.†

102. I desire the reader to remember, that field-works in general, and particularly small ones, are very frequently thrown up in haste, wherefore their construction cannot be attended to with as much care as that of permanent works: besides, even a good soil, which has been newly moved, has not a sufficient consistence to form a very solid mass,

* Such works are commonly thrown up to cover small posts which are not intended for any actual defence, but to keep upon guard and give alarm; as, for instance, the grand guard of an army, &c.

† A work of this kind may be constructed, when the troops which defend it can shortly be supported by others, and when it is necessary that they should resist, in order to facilitate the execution of such movements as may take place; and likewise, when troops are compelled to intrench themselves in haste, as an attack is shortly expected.

and as the interior and exterior slopes of the parapet are made steeper than that which loose earth naturally takes, when thrown up in a heap, the parapet has a tendency to crumble down; therefore, should its thickness not exceed the dimensions, which it strictly must have not to be pierced through, in the beginning of the attack, by the projectiles which strike it, its top would soon after be carried off and leave the defenders uncovered: lastly, the continual percussion of the shot causes degradations in some of its parts, and as it cannot be thickened again during the attack, it follows that it would soon be liable to be pierced through.

103. If a work is intended to resist cannon shot, the nature of the guns which the assailants will probably bring against it, according to its importance, must also be considered.

Should they be 4 or 8 pounders,* and the soil tolerably good, 6 feet will be enough, fig. 81, for

* The dimensions which I here propose, with regard to the requisite thickness of the parapet of field-works which may be attacked with cannon, and in the various cases that may occur, are founded upon the effect of such guns as are generally used by the French in the field; the reason is, that an officer should be made acquainted with the effect of his enemy's arms, which he may not have the possibility of ascertaining at all times; whereas, on the contrary, he can easily get information about the weapons used in his own country.

the thickness of the parapet, provided that, in the latter case, it can be battered only from a distance and for a short time.*

104. But if a work, fig. 82, which should resist 8-pounder shot, may be battered from near points, and for a length of time, its parapet requires a thickness of 8 and even 9 feet, according to the nature of the soil.

105. No less than 10 feet should be allowed for the thickness of the parapet of a work, fig. 83, pl. 19, which must resist for some time 12-pounder shot; and particularly if the assailants can place their cannon at a short distance from it: I here suppose that the soil is good; should it be bad, or should the attack be likely to last for a long time, the thickness of the parapet must be increased to 12 feet, as in fig. 84.

106. The French do not generally bring into the field larger guns than 16-pounders; and as a work, fig. 85, which is intended to resist such guns, is of great importance, a very obstinate and powerful attack must be expected: therefore the thickness of the parapet, in this case, should not be less, in general, than 15 or 16 feet; however, should the points, where the assailants may place their cannon,

* This depends on the nature of the ground which surrounds the work, and on the means which the garrison may have to be shortly and effectually supported.

be at a certain distance from the work, and the soil very good, a thickness of 14 feet might suffice, as in fig. 86, pl. 20.

OF THE INTERIOR AND EXTERIOR SLOPE OF THE PARAPET.

107. The more inclined the interior slope *a c* of the parapet is (vide pl. 18, 19, and 20, fig. 78, &c.), the less easy it will be for the men to approach its crest, and to fire over it in a proper direction; wherefore its base should not be more than 12 or 18 inches, at most, according to the nature of the soil, and the elevation of the parapet; indeed, the former dimension must be exceeded as little as possible.*

108. With regard to the requisite inclination of the exterior slope *e f*, it chiefly depends on the nature of the soil used in erecting the parapet, and on

* According to Clairac, Bousmard, and almost all authors, one-third of the height of the parapet should be allowed to the base of its interior slope; but if we only suppose that the parapet is 6 feet high, the immense inclination of this slope will be very prejudicial to the effect of the musketry fire, and without procuring any other advantage than that of rendering the slope more firm; what would then be the case, should the parapet be higher than 6 feet? It is undoubtedly better not to make the interior slope so much inclined, and to support it by means of a revêtement.

the greater or less solidity which the work requires according to its object, the length of time for which it ought to stand, the nature and probable duration of the attack which it is intended to resist, and to the proximity of the points where the assailants can place their cannon, should they use it; the height of the parapet must also be considered.

109. Before I enter into further particulars on this subject, I shall observe that the slope which loose earth naturally takes, when thrown up in a heap, and without precaution, forms the hypothenuse *d b* of a rectangular triangle *d a b*, pl. 20, fig. 87, whose base *a b* is equal to its height *a d*, if the soil is compact; and to once and a half its height, as *a c*, if it is sandy, since the slope increases in proportion as the soil is lighter; and that a mass formed with loose earth, which has been laid on by beds, and carefully rammed, will not support itself firmly, unless the base *a e* of its slope, same fig., is equal to $\frac{1}{3}$ of the height *a d*, if the soil is good; to $\frac{1}{2}$, as *a f*, if it is indifferent; and to $\frac{2}{3}$, as *a g*, if it is sandy or stony. I here suppose that this mass is not exposed to the percussion of any projectiles, and since the parapets of field-works are exposed to it, the base of their exterior slope must, in general, be greater.

110. Let us now suppose that a work of little consequence, pl. 18, fig. 78, should resist only the

first musketry fire, and stand for a few days; as its construction will not then require great solidity, it may suffice, indeed, that the base nf of the exterior slope ef be equal to $\frac{1}{3}$ of the whole height ag,* if the soil is good, to $\frac{1}{2}$ if it is indifferent, and to $\frac{2}{3}$ if it is bad; but if a work which is intended to resist only musketry fire, fig. 79 and 80, should stand for some time, or make a certain defence, $\frac{1}{2}$ of that height must be allowed, if the soil is good, $\frac{2}{3}$, if it is indifferent, and the whole, if it is bad.†

111. When a work, fig. 81 and 82, is intended to resist cannon shot, and particularly if it is to stand for a certain time, not less than $\frac{1}{2}$ of the whole height ag, or thereabout, should be allowed to the base nf of the exterior slope ef, if the soil is good, $\frac{2}{3}$, if it is indifferent, pl. 19, fig. 85, and the whole, if it is bad.

* Authors generally recommend to make the base nf, of the exterior slope, an aliquot part of en; but the method which I propose will be found more convenient in practice, and no defects will arise from the small additional length which it gives to the base nf.

† The base of the exterior slope of a work which should stand for some time, must evidently be larger than that of another work which has been constructed only for a few days; since the former is exposed for a longer time than the latter to the pressure of the parapet and the swelling of the earth, as well as to the degradations occasioned by rain, heat, &c.

It is very important to regulate properly the inclination of the exterior slope of field-works: for, when it is too steep, it has no sufficient solidity, and is liable to crumble down, as well as the parapet; and should it be gentle, beyond the requisite proportion, the escalade would be easier.

OF THE BERM.

112. I have hitherto supposed that the exterior slope of field-works formed one continued surface, from the exterior crest of the parapet, down to the bottom of the ditch, and this construction should be in general recommended, for it renders the escalade more difficult; but the reader has seen, that either on account of the badness of the soil, or because the parapet is much elevated, the solidity of the work requires, sometimes, that the inclination of its exterior slope should be very great; and as in this case the slope is easy to ascend, a berm *i r*, pl. 19, fig. 83, may be constructed, which divides it in two, and allows you to make it steeper.*

* It is evident that the part *r f* of the slope may be made even steeper than *e i*; as it is not formed with earth newly moved, and is not exposed to the enemy's shot.

A berm has the defect, however, and especially when it is not flanked, of affording a convenient place where the assailants can rally and take breath during the assault; and as this defect increases in proportion as the berm is wider, not more than 20 or 24 inches should be allowed to its breadth, unless the soil is extremely bad, or the parapet very high.*

113. The works of many authors contain profiles, where, as in pl. 20, fig. 88, the berm is placed on the horizontal ground *b c*, and the elevation of the exterior crest *a* of the parapet above it not greater than 4 feet: this construction is very defective; first, because the assailants may easily climb the part *a c* of the escarp; and, secondly, because they may take in front, in flank and in reverse the defenders of the work, who only see them in front, unless the berm is flanked;† therefore, the vertical distance from the exterior crest

* Every reader knows that the object of the berm is to prevent the escarp from giving way, on account of the pressure of the parapet upon it; but this object may be attained, when the soil is good, and the elevation of the parapet moderate, without giving to the berm such an immense breadth as 3 and even 4 feet, as many authors do. Clairac proposes to make the berm sloping or circular.

† It is to be observed, likewise, that the assailants, when they stand upon the berm, receive as much protection from the parapet in their front, as the men who defend it.

of the parapet to the berm should not be less than 5 feet 6 inches or thereabout; and if the elevation of that crest, above the horizontal ground, is smaller, the berm must be sunk, as in fig. 89.

It follows from the preceding observations, that a berm is defective in itself; and that it should be used only when the soil is bad, or the parapet uncommonly high; when the soil is good, and the parapet not higher than about 8 feet, a berm is generally useless.

OF THE SUPERIOR SLOPE OF THE PARAPET.

114. The superior slope *a e* of the parapet of a field-work (vide pl. 18, 19, and 20, fig. 78, &c.) should always be directed to the summit *m* of the counterscarp, when no inconveniency arises from it; for as the enemy is particularly exposed to the effect of our fire, when he is close to the ditch and stopped by it, we should then pour shot on him; besides, it has been proved by experience, that a soldier behind a parapet fears to uncover himself, and stoops in firing, which generally raises his shot above the direction of the slope; and, lastly, the assailants commonly stoop, when they are near the work.

115. There are circumstances, however, such as the narrowness of the ditch, &c. where an engi-

neer is compelled, notwithstanding the inconveniencies arising from it, to direct the superior slope of the parapet to a point *s* beyond the counterscarp, as in fig. 78 and 81, pl. 18,* in order not to weaken, beyond measure, the interior crest *a* of the parapet, which, should the work be attacked, and particularly with cannon, would soon be pierced and destroyed.†

Besides, the attitude in which a soldier must place himself to fire in the direction of the superior slope of the parapet, raises the but end of his gun in proportion as the slope is more inclined; therefore, should its inclination exceed certain limits, the men could not take aim, and particularly those of small size. I shall lay it down as a rule, that the superior slope of the parapet must not be more than 15 inches per toise, or 18 inches at most,‡ and that 1 foot will suffice when the

* Care must be taken in this case, that the prolongation *e s* of the superior slope be not elevated more than 3 feet above the top *m* of the counterscarp; and should circumstances require a greater elevation, a glacis must be constructed. I shall enter hereafter into the particulars relative to glacis in general.

† It is particularly dangerous to weaken, beyond measure, the interior crest of the parapet, when the command of the work is small; as the direction of the shot is then nearer to being horizontal.

‡ Nay, it has been proved by experience, that a man of small size cannot fire easily, in the direction of the superior slope, when

command of the work is not greater than 6 feet, or thereabout.

OF THE BREADTH AND DEPTH OF THE DITCH, AND OF THE SLOPE OF THE COUNTERSCARP.

116. As the construction of field-works does not require, in general, a great quantity of earth, it follows that the ditch, from which it is supplied, has commonly a small breadth and depth.

An engineer should be very cautious in regulating the dimensions of the ditch; for, if, on the one hand, they ought to allow a sufficient supply of earth, care must be taken on the other, that they do not exceed proper bounds; the reason is, that should they be much greater than are wanted, a quantity of earth would remain, after constructing the work, which should be dispersed here and there, not to afford any cover to the assailants in their approach; and, therefore, time would be lost and much labour thrown away: besides, the breadth and depth of the ditch must have certain fixed dimensions; for should its breadth be small, beyond measure, in order to make it deèper, not

its inclination is 18 inches per toise, and even supposing, that the interior crest of the parapet is not higher than 4 feet above the banquette, as I shall recommend.

only the assailants could easily pass it with planks or trunks of small trees laid across, but the superior slope of the parapet would frequently require an excessive inclination, which, as the reader has seen No. 115, is very prejudicial to the defence; a sufficient number of convenient tools may likewise not be at hand, and even supposing that they can be procured, earth is not easily thrown up with a shovel from a certain depth; thus it must be carried from hand to hand, which requires much time and a great number of workmen; or ramps and a quantity of wheel-barrows must be used, and this is very seldom practicable in the field.

117. When a work has flanks, it becomes still more important to regulate properly the depth of its ditch; for it is evident, that the inclination of the superior slope of the parapet being the same, the distance from those flanks, at which their musketry fire will meet the bottom of the ditch, is so much greater as the ditch is deeper; and should the inclination of the superior slope be inconsiderately increased, in order to make that distance shorter, then the work would be exposed to the inconveniencies arising from the excessive inclination of the superior slope, which I have explained.

If we now suppose that a proper depth has not been allowed to the ditch, in order to increase its breadth, it will be easily filled up, if it is wet;

and in case it should be dry, the assailants will have less difficulty in climbing up the exterior slope.

It has been determined, after the preceding considerations, that not less than 5 or 6 feet should be allowed for the depth *q m* of the ditch, pl. 18, 19, and 20, fig. 78, &c. and that this depth, which is suitable only to works which require a small *remblai*, may be gradually increased to 12 feet, in proportion as the profile of the work is greater. With regard to the breadth *r m* of the ditch, it should be 7 feet at least, and augmented by degrees, in proportion to the *deblai*.*

118. I shall conclude with observing, that the slope *p m* of the counterscarp should be as steep as possible, according to the nature of the soil; for the steeper it is, the more difficult it will be to the assailants to descend into the ditch, and re-ascend upon the counterscarp, should they be repelled. When the soil is good, $\frac{1}{2}$ and even $\frac{1}{3}$ of the height *q m* of the counterscarp, will suffice to the base *p q* of its slope.†

* *Remblai* and *deblai* are two French expressions; the first of which signifies the mass of earth that is wanted to construct a work; and the second, that which is procured from the excavation of the ditch.

† There is no danger in making the slope of the counterscarp as steep as possible, according to the nature of the soil; for it is not formed with earth newly moved, and it is little exposed to

OF THE BANQUETTE AND ITS SLOPE.

119. I have asserted, in No. 91, that a man of common size could fire in a horizontal direction about 4 feet 6 inches above the ground where he stands; and now observe, that this elevation is the greatest which allows the but end of his musket to be firmly supported by his shoulder: I have explained likewise, No. 115, that the attitude in which a soldier can fire in the direction of the superior slope of the parapet, raises the but end of his gun, and so much more as this slope and the interior slope are more inclined; therefore, the height of the interior crest *a* of the parapet above the banquette *c d*, pl. 18, 19, and 20, fig. 78, &c. should be less than 4 feet 6 inches, although this dimension is recommended by almost all authors who have written on field-fortification; for it is evident, that it prevents the soldier from firing in the direction of the superior slope, and that his shot, which is raised above it, passes over the heads of the assailants, especially when they are near the work.* I shall lay it down as a rule, that

the enemy's shot; besides, it has no parapet to support, and even supposing that some of its parts might fall dawn, it will not prejudice the defence.

* Besides, I beg the reader to recollect what I have explained in No. 114; namely, that a soldier who stands behind a

the elevation of the interior crest of the parapet, above the banquette, should be only 4 feet, and particularly when the work may be immediately attacked, as it is not to be expected that the sinking of the earth will then produce any material alteration on the height of the parapet; indeed, the men are not so well covered, when the elevation of the interior crest of the parapet, above the banquette, is only 4 feet, as when it is 4 feet 6 inches; but the effect of the musketry fire is far more certain, which should be preferred.

I now observe that whatever may impede the troops in their motions, or create confusion, should be carefully avoided; and particularly when a work is to make a certain defence: whence the breadth of the banquette, which depends on the number of ranks in which the garrison is to be placed, and on the importance of the work, should be such as to allow a free passage behind the men who line the parapet; particular care should also be taken, that the slope of the banquette is easy to mount and descend.*

parapet stoops in firing, which raises his shot, and that the assailants also stoop when they are near the work.

* The same attention should be paid to the slope of those parts where guns are to be placed, and it must be such as to allow the artillery men to get them easily up and down. When the parapet of a work is much elevated, the slope of the banquette may be diminished by constructing it in the form of steps, *h i l*, as in

Conformably to the preceding observations, 3 feet are requisite, for the breadth *c d* of the banquette, in small works, where the troops are disposed only in one rank; but should they be formed in more than one rank,* 4 and even 5 feet are required, according to the importance of the work.

With regard to the base of the slope *d h* of the banquette, it requires 5 feet at least, when the height of the parapet is 6 feet;† and it should be gradually increased, in proportion as the parapet is higher and the work more important.

fig. 84, pl. 19, which should be 10 or 12 inches high, and 15 or 18 inches broad.

* In this case, the 1st and 2d ranks should stand on the banquette, and the 3d rank or the reserve on the terreplein, in order to remove from the banquette the men who are killed, assist those who are wounded, fill up the vacancies in the 1st and 2d ranks, and reinforce such points as may require it; it is proper likewise that the men in the 1st rank only should fire, and that the muskets should be loaded and handed to them by those in the 2d, whose fire would only occasion a waste of ammunition.

† This dimension may appear considerable, as many authors recommend 3 feet only; experience proves, however, that a steeper slope is inconvenient in most respects, and that it is scarcely suitable to small works, pl. 18, fig. 78, from which a trifling resistance is expected; besides, when the slope of the banquette is gentle, the men may lie more easily upon it, and therefore the greater space which it occupies is fully compensated for by that conveniency.

120. Ramparts are sometimes thrown up round the whole contour of large and very important works, pl. 19 and 20, fig. 85 and 86, whose parapet is much elevated; or only in such parts as are to contain guns, which requires less time and labour: their breadth should be determined according to the time which the engineer can command, the importance of the work, the extent of its interior surface, and particularly to the number and nature of the guns which it is to contain. Ramps are made as near as possible to the parts where the cannon is to be placed, and serve as a communication from the inside of the work to the terre-plein *h s* of the rampart.

When there is a rampart, the breadth of the banquette and the base of its slope are sometimes reduced to less dimensions than those which I have recommended; such construction, however, which the narrowness of the rampart may occasionally require, is very defective in itself, and should be avoided as much as possible.

OF THE REVETEMENT OF FIELD-WORKS.

121. When a field-work is to stand for some time, its solidity should be increased by means of a revêtement constructed along its interior and exterior slope, and which may be made in different

ways, according to the nature and quantity of materials which you have at hand: the number of workmen and the time which you can command must also be considered.*

122. Turf, *a*, pl. 20, fig. 90, forms a good revêtement, as it supports the earth, renders the work less liable to be damaged by the inclemency of the weather, and allows you to make the exterior slope *b c* steeper, provided the work is to resist only musketry; for, should it be attacked with cannon, as the turf will not prevent the penetration of the shot and the crumbling down of the parapet in those parts better than earth alone would, the inclination of the exterior slope, in this case, ought not to be diminished, as many authors erroneously recommend.

123. A revêtement made with saucissons, *a*, pl. 21, fig. 91, is better than the preceding, as it gives a greater solidity to the work, and opposes a certain resistance to the shot of small guns.

124. Small trunks of trees, or logs, *a*, laid upon each other, as in fig. 92, make a revêtement still stronger than saucissons; but it has this inconve-

* When you are in haste, and particularly if the work is of little importance, small branches, and even straw, may be intermixed with the earth of which the parapet is formed, so as to render it more compact; but such means will not much increase the solidity of the work, and you should use it only when you cannot do better.

niency: it requires that the inclination of the exterior slope should be great, in order that the logs may be steady; and they form steps *b*, by means of which the assailants may easily climb up the work, and descend it if they should be repelled; therefore such revêtement does not suit works which are liable to be briskly attacked, as it weakens their defence; and it is only fit for those which, on account of their great importance, and of the strong resistance required from them, have been so calculated as to demand a regular attack.

125. A revêtement may also be formed by means of timber work *a*, fig. 93 and 94; and, in this case, the slopes which it supports may be made much steeper, which is a great advantage: as such revêtement, however, requires a considerable time, professional workmen, and a supply of proper materials, which cannot always be procured, its use is limited to some particular circumstances.

126. Other methods have also been proposed to form the revêtement of field-works; but they are attended with such difficulties in practice, that it is next to an impossibility to use them; and therefore I shall not enter into any further particulars on their account.

I shall conclude with observing, that the revêtement of the interior slope requires still greater precautions than that of the exterior one; as, on account of its steepness, it is more liable to crum-

ble down: turf, fascines, saucissons, and hurdles, are generally used for its construction.

OF PALISADES AND FRAISES.

127. Palisades can be quickly and easily constructed: besides, the materials which they require are found in most places; wherefore they are frequently used in the field, not only to impede the assailants in their attempt to cross the ditch, and escalade the parapet of a work, but also to prevent their approach to the counterscarp; I shall first explain the best method of disposing them in the former case.*

128. Palisades may be placed in various manners, according to circumstances; and the disposition which they require depends on their number, the time which you can command, the depth of the ditch, the nature of the work which is to be palisaded, and on the defence it should make, according to its importance.

129. When a work is not very important, or should your supply of palisades be small, they ought to be placed in one row; and the best man-

* The method of disposing palisades, when they are intended to prevent the assailants from approaching the counterscarp, shall be explained when I treat of covert-ways, glacis, and avant-glacis.

ner of disposing them, in this case, is to plant them at the foot of the counterscarp, with a little inclination towards the country, as *s*, pl. 19, fig. 83; but when you construct two rows, one should be placed as aforesaid, and the other vertically at the foot of the escarp, as *t*:* lastly, if more than two rows are constructed, one may be also placed either in the escarp, as *u*, or upon the berm, as *w;* and even in both places, supposing that the depth of the ditch, the time which you can command, and the number of palisades which you have at hand, will allow it.†

* According to some engineers, the palisades placed at the foot of the escarp should be inclined towards the country, as *s*, fig. 84, in order that the enemy may have greater difficulty in cutting them or pulling them down; but in this situation they are more exposed to the ricochet than when they stand upright: besides, should the work have flanks, or *palisade-caponières*, of which I shall speak hereafter, it is evident that their fire would be obstructed by the palisades.

† When a work may be attacked with cannon, palisades placed in the escarp, as *u*, fig. 83, or upon the berm, as *w*, must be covered from the direct fire of the artillery, either by the top *m* of the counterscarp, or by a glacis *n;* and therefore, should there be no glacis, the berm must be sunk, as in pl. 20, fig. 89, if you intend to place palisades upon it. Of all the dispositions which I have recommended, those represented by the palisades *s* and *t*, fig. 83, are undoubtedly the best in general; but they are not applicable to all circumstances; for, should there be any outworks, as palisades placed in the bottom of the ditch would obstruct the communication with them, I should prefer, in this case,

130. I shall here observe, that very small works, whose ditches, therefore, require a very small breadth, should not be palisaded; for palisades cannot stand firmly, unless one of their ends be sunk about $2\frac{1}{2}$ feet into the ground; and should not the other project from $4\frac{1}{2}$ to 6 feet and upwards, according to the place which the palisades occupy, they would scarcely oppose any obstacle to the assailants in crossing the ditch and escalading the work: thus, the smallest length which may be allowed to them is 7 feet. Now, let us suppose that the breadth $r\,m$ of the ditch, pl. 18, fig. 78, is only 7 feet, or thereabout, and that the work is palisaded, it is obvious that the assailants, after pulling up the palisades, may lay them horizontally across the ditch; and as, in that situation, they are supported at both ends by the slopes of the escarp and counterscarp, they will form a bridge, and enable the assailants to escalade the work with greater facility.

131. Several other methods of disposing palisades have also been proposed; namely, in the middle of the ditch, either in a vertical or oblique direction, as t and u, pl. 19, fig. 84; or parallel to the slope of the counterscarp, and at 2 feet from it, as w; and, lastly, upon the banquette,

to place the palisades in the escarp, or upon the berm, notwithstanding the inconveniencies arising from it in other respects.

as x, with their points from 6 to 12 inches higher than the interior crest of the parapet. (Vide the Works of Tielke, Struensee, Cessac Lacuée, &c.) But these methods are very defective: first, if a work have flanks, palisades placed in the middle of the ditch will obstruct their fire, and shelter in some measure the assailants; particularly if the palisades are oblique; and should the work have no flanks, in which case I would recommend to construct palisade-caponières, of which I shall speak hereafter, this effectual means of defence could not be used: secondly, when palisades are placed in a direction parallel to the slope of the counterscarp, and at 2 feet from it, they afford a footing to the enemy, between them and the slope, which he has not when they are planted as s, fig. 83, conformably to the method which I have explained;* and therefore he can cut or pull them

* When palisades are disposed in this manner, it is very difficult to the enemy to cut or pull them down; for he should place himself for that purpose between them and the slope of the counterscarp; and in this situation, which is so much the more inconvenient to him as he has no footing, he can scarcely handle an axe or a lever.

It is to be remarked, that, should the garrison mount upon the top of the parapet, they could defend from it palisades placed near the counterscarp, and that on account of the thickness of the parapet they cannot protect those which are disposed according to any of the other methods which I have explained, unless the work has flanks.

down with greater facility: lastly, palisades planted on the banquette, and 6 or 12 inches higher than the exterior crest of the parapet, present no obstacle to the assailants in their attempt of escalading the work; besides, they are exposed to their cannon, and dangerous for the garrison on account of the splinters: it is evident, likewise, that they prevent the men from firing as conveniently as they would without them. With regard to the fraises *y*, which most authors recommend to place toward the top of the parapet, they are undoubtedly of no use to the actual defence; for their elevation exposes them entirely to the sight of the assailants, who will destroy them with their cannon, from the beginning of the attack, and long before they attempt to escalade the work: fraises may be useful, indeed, to prevent surprises and desertion; but palisades placed in the bottom of the ditch, or in the escarp, answer the same purpose, at least with regard to surprises; and they have the advantage over fraises of being not so much exposed to the enemy's cannon; therefore fraises should be used only as an additional precaution against surprises and desertion; and they are particularly applicable to very important works which may be constructed at ease, and with an abundance of wood at hand.*

* Fraises might be of service in strengthening small works which are not intended to resist cannon shot; but even supposing

132. Trunks of trees, *t*, fig. 85, from 10 to 12 inches in diameter, and from 10 to 12 feet in length, augment considerably the strength of a work, when placed vertically and close to each other at the foot of the escarp; they should be sunk into the ground from 4 to 5 feet, and elevated 6 or 7 feet above the bottom of the ditch, so as not to be liable to be climbed up by the assailants, who have great difficulty in cutting them down with axes; and particularly if the ditch is seen from any flanks: now, in order that they may be destroyed by cannon, the guns ought to be placed upon the edge of the counterscarp, and purposely directed against them; for no shot, fired from a certain distance, and which may accidentally hit them, will sufficiently damage them to enable the assailants to reach the exterior slope suddenly, and to escalade the parapet.*

133. Palisades and logs are used likewise to construct *palisade-caponières*, the object of which is to defend the ditch (when it is dry) of works which have no flanks: should palisade-caponières be made only with palisades, and the attack be

that you may command the necessary time, number of workmen, and quantity of wood, to avail yourself of that additional means of defence, such works scarcely require it.

* It is scarcely necessary to point out, that the use of logs, instead of palisades, is particularly applicable to important works, which may be attacked with cannon.

supported by cannon, they ought to be repaired, as well as possible, as the shot damage them; for, should this precaution be neglected, the caponières might be in such disorder, at the time when the enemy attempts to cross the ditch, that they could not oppose him any obstacle: but when they are made with logs from 10 to 12 inches in diameter, no repairs are particularly requisite, since it has been explained that no shot could damage them materially, if fired from a certain distance.

The form of the palisade-caponières, and the part of the ditch where it is proper that they should be placed, depend on the nature of the work to which they are adapted, and on the number of points where it may be attacked: let it be a redan, for instance, pl. 21, fig. 95, whose gorge *a b*, is so well supported that it cannot be turned; as it presents only a saliant *c* to the enemy, a caponière, *e*, which, in this case, may be composed of a simple row of palisades or logs, should be constructed at the extremities *b* and *d* of the faces, and as much as possible in a direction perpendicular to them, without exposing its defenders to be taken in flank or in reverse; the palisades, as well as the logs, should be close to each other, as is represented by fig. 96, 97, and 98, and sunk $2\frac{1}{2}$ feet or 3 feet into the bottom of the ditch, so that their points may be elevated 6 feet above it. The thickness of the palisades should not be less than

about 3 inches, in order to prevent their being pierced through by the bullets.*

That the soldiers may fire from behind a palisade-caponière, loop-holes *a*, fig. 96, 97, and 98, should be made at every $2\frac{1}{2}$ or 3 feet,† either by cutting two palisades or logs in the same manner as in fig. 97 and 98, or by leaving at proper distances a space *a* 3 inches wide (see fig. 96), which is filled up afterwards by a palisade *b*, whose height above the bottom of the ditch should be 4 feet 6 inches at most.

134. When you can command a sufficient time and supply of palisades or logs, the palisade-caponières, of which I have been speaking, should be constructed as those *e* in fig. 99, pl. 22: the advantage of this disposition over the former is, that troops protected by the caponières *e*, may, by means of the tambours *f*, sally upon the flanks of the assailants when they attempt to cross the ditch;

* I here enter into particulars respecting the construction of palisade-caponières, as some of my readers may not know the method of making them.

† Three feet are usually allowed for the distance between the loop-holes; but, as a palisade-caponière has in general no great length, I think that they would be better placed at only $2\frac{1}{2}$ feet asunder; the quantity of fire would be encreased by this means, and the men could load and fire with as much facility, as they generally stand sideways, not to expose themselves to be struck through the loop-holes.

and, that those sallies, when opportunely made, produce always a great effect.

135. If, instead of a redan, we now suppose a redoubt, *a b c d*, pl. 22, fig. 99, whose sides *a b*, *b c*, *c d*, and saliants *b*, *c*, may be attacked, it is evident that only the ditch of the sides *a b*, *c d*, will be defended by the fire of the simple caponière *e*, constructed at their extremities, and that the ditch of the side *b c* is not protected; in this case, construct a *double palisade-caponière* within it,* that is, plant across it two rows of palisades or logs, *g h*, *i k*, and allow 6 or 7 feet for the distance between the rows; lay cross-wise, upon the top of the palisades or logs, pieces of wood 4 or 5 inches square, on which thick planks, fascines, &c. are placed, so as to form a roof *x* (vide fig. 101 and 102), which you should cover afterwards with turf or earth, &c. to a height of 1 foot or thereabouts, and whose object is to cover the soldiers who defend the caponière from the musketry fire, grenades, and stones, with which, without it, the enemy might assail them from the top of the counterscarp.

To communicate from the inside of the work with the caponière, a gallery *a b c d*, 4 or 5 feet

* Should the side *a d*, and the saliants *a* and *d*, be also liable to be attacked, a double palisade-caponière is requisite on every side of the redoubt, since the single caponière *e* affords no protection to the side *a d*, and may be turned.

wide and about 6 feet high (see fig. 101), is constructed, which passes underneath the parapet, and whose top and sides are supported by timber-work *h;* the ramp *a d,* which forms the descent of the gallery, should be easy.

The most convenient and expeditious method of constructing the gallery is, first, to make the ramp *a d;* next, to place the timber-work *h;* and lastly, to raise the parapet over it.

Should the caponière extend from the escarp to the counterscarp, the assailants could use it as a bridge; they would likewise uncover part of its roof from the counterscarp, and throw into it grenades and fire-works: in order to avoid those inconveniencies, the caponière must be separated from the counterscarp by a ditch *m* 7 feet wide or thereabout, fig. 99 and 101, and it should be covered near the escarp only from the palisades *n* of the work.

136. The reader may easily conceive that a double palisade-caponière, constructed after the method which I have explained, increases considerably the defence of the ditch; however, it has this defect, namely, its head *h k*, fig. 99, and the small ditch *m*, are not well defended; for, although the head of the caponière is pierced with loop-holes *r* (see fig. 101 and 102), yet their fire is so weak, and the assailants may so easily secure themselves from it, that you ought not to depend on its effect.

137. The method represented by fig. 100, and which has been proposed by the French General Montalembert, is far preferable: according to this method, the head of the palisade-caponière forms a point *b a c*, that is defended, as well as the sides *b e*, *c f*, and the ditch *d*, by a reverse fire from the parts *h g e*, and *f i k* of the palisades of the work, which the General disposes in such a manner as to form the flanks *h g*, *i k*, and the kind of curtain *g i*, behind which fusiliers are placed; however, as his construction requires the exterior slope of the work, behind those parts, to be made steeper, and that it should be firmly supported either with timber-work or saucissons, it increases the labour, and may occasionally give rise to inconveniencies; therefore it is not applicable to all circumstances, but it should be used whenever nothing prevents it.*

138. That a palisade-caponière may be less exposed to the enemy's ricochet, and particularly when it is made with palisades, or with logs whose diameter is small, it is proper that its bottom, *e f*, (vide fig. 101) should be lower than the bottom *d g* of the ditch; and that a glacis *p* should be con-

* When you have time, and a sufficient number of workmen, trous de loup *a*, fig. 102, of which I shall speak hereafter, should be disposed along the sides of palisade-caponières, in order to prevent the assailants from insulting them on a sudden.

structed, in order to raise up the counterscarp as much as the relief of the work will allow.*

OF ABATIS, CHEVAUX-DE-FRISE, HARROWS, CROW'S-FEET, PICKETS, AND TROUS DE LOUP.

139. Abatis, properly so called, consist, as the reader knows, of trees cut down, which are placed close together, and upon one another, so that their branches are presented towards the enemy, and their trunks towards the work; he is aware, likewise, that they are used either as intrenchments, or to stop passages, and I shall only observe, that trees of a moderate size are preferable, in general, to large ones, as they may be more easily conveyed, obstruct less our fire, and require less trouble in preparing.†

140. An abatis may also be formed with large branches of trees, which, according to circumstances, should be carefully disposed, either along

* This precaution is particularly requisite when the ditch has no great depth.

† The proper formation of an abatis requires that the small branches which can not oppose a sufficient resistance should be cut off; and that the others should be cut obliquely underneath; so that their points may form several rows, one behind another, without the abatis being too much elevated, as in this case it would greatly obstruct our fire, and be much exposed to the enemy's sight.

the slope of the counterscarp, as *n*, pl. 20, fig. 86, or upon the berm,* (in case you are compelled by the very bad quality of the soil to allow it 5 or 6 feet in breadth) and in other places, which I shall explain;† an abatis of this sort is preferable in general to palisades, as it is less liable to be destroyed by the enemy's cannon: besides, its construction requires only a short time, and proper branches are easily found; in order that the assailants may have a greater difficulty in removing the abatis, the branches should be fastened to the ground by means of strong pickets forming a hook, and their thick end be buried 2 or 2½ feet into it.

141. Chevaux-de-frise are very useful to secure the entrances of field-works and intrenchments; they may also be used to advantage behind certain glacis, as it shall be explained; but I am far from coinciding in opinion with many engineers who recommend placing some in the bottom of the ditch; as *c*, pl. 21, fig. 92; for in that situation, they enable the assailants to fill it up more easily,

* The branches, in this case, should be laid horizontally across the berm.

† Noizé de St. Paul, and other engineers, recommend to place abatis of this kind upright along the slope of the escarp, as *o*, pl. 20, fig. 86, and horizontally in the bottom of the ditch, as *d*, fig. 68; but in the former disposition they may serve as ladders to escalade the parapet, (unless the work has a great relief,) and in the latter, they facilitate the means of filling up the ditch.

and they may serve them as ladders to escalade the parapet.

With regard to the method proposed by some authors to place chevaux-de-frise upon the berm, as *c*, fig. 93, and in front of the work, as *d*, fig. 92, without being properly covered by a glacis: this method, which is scarcely applicable to field-works intended to resist musket-shot only, is so absurd, when an attack with cannon may be expected, that it deserves no further commentary.

142. Harrows, laid with their points upwards, and firmly fastened to the ground, may be considered likewise as an obstacle to the assailants; but it is difficult to collect a sufficient number of them, and such means of defence can seldom be used in the field: it is the same thing with crow's-feet, a considerable number of which is wanted to throw some obstruction in the way of the enemy, who can, besides, easily remove them.

143. Pickets *b*, pl. 21, fig. 93, from 1 to 2 inches in diameter, or thereabout, and from $2\frac{1}{2}$ to 3, or $3\frac{1}{2}$ feet in length, afford a very good defence, when placed, chequer-wise, at a small distance from one another;* they should be pointed at both ends, rather inclined towards the assailants, and sunk

* The requisite distance asunder of the pickets can scarcely be determined, as it depends on their number, and on the extent of the ground where they are to be planted; but they should be as near to each other as possible.

18 or 20 inches into the ground, that they may not be easily pulled up.

144. Trous de loup present a formidable obstacle to the assailants, and particularly when they are disposed chequer-wise in several rows, as those represented by *s*, in pl. 23, fig. 106; it is known that they are holes commonly made in the shape of the frustum of an inverted cone (see the trous de loup *b*, pl. 21, fig. 91) and which are placed at a distance of 9 or 10 feet asunder from centre to centre; their diameter at top is in general from 5 to 6 feet, and from 20 to 24 inches at bottom: with regard to their depth, it varies from 4 to 6 feet, or thereabout, according to their construction, and a picket, from 2 to 3 inches in diameter, is placed vertically in their centre, whose top, which is pointed, should be about 6 inches lower than the edge of the trous de loup.

145. The earth supplied from the excavation of the trous de loup, is frequently laid in a heap and sloping, in the intervals betwixt them, as in pl. 25, fig. 112; sometimes, on the contrary, it is spread about, so as to form no elevation which may favour the assailants (see pl. 26, fig. 115); the former method requires undoubtedly less labour than the latter, since the depth of the trous de loup, which is increased by the height of the earth supplied from their excavation, may be made smaller; I own likewise, that as this earth, which obstructs the passage

between the trous de loup, is laid loose and sloping, it may give way when walked upon, and affords, therefore, no firm footing to the assailants who are exposed to fall into the trous de loup; it is not less true, however, that elevations are thus formed, whence the enemy may plunge their fire into the work, unless the height of the parapet is sufficient to remove that inconveniency, and then it should be 7 or 8 feet; moreover, the earth placed between the trous de loup may serve to fill them up; I think, therefore, that this method has not in general such advantages over the other as many engineers imagine, and particularly when the trous de loup can be placed at no greater distance asunder than 2 feet or thereabout.

146. I now observe, that when trous de loup are made in a ditch where palisades are planted, pl. 21, fig. 91, the latter must be placed behind the former, as *d*, for instance; for, should they be in front, as the palisades *c*, the assailants, after pulling them up, could use them as a bridge to cross over the trous de loup.

OF INUNDATIONS, &c.

147. The reader knows, that in order to form an inundation, the current of a stream is stopped by means of dams, *a*, *b*, pl. 23. fig. 103, thrown across its bed, and the lowest parts of the adjacent

ground; so that the water, as it cannot run off, swells above the banks, and overflows the country.

148. An inundation may be intended to cover whole *lines*, or only part of them: it may also be formed merely with a view of augmenting the security of a post, or of an isolated work.

149. In the two former cases, and particularly in the first, the inundation generally requires a great extent, and therefore much time and labour; besides, an inundation of this magnitude hurts the country which it covers; it may occasion dangerous diseases, and the dams are so many posts which must indispensably be guarded night and day, not only to secure them from the enemy's enterprises, but in order to prevent their being damaged, and, perhaps destroyed, by a considerable and sudden swelling of the water, occasioned by a heavy rain, or by the melting of the snow, if it is in the winter: Lastly, a hard frost may render it useless; therefore, however effectual inundations of this kind may be, when they answer their object, they should only be formed in such circumstances, as greatly require them, and after having weighed their advantages, and inconveniences. The defects of which I have been speaking, are removed in a great measure, when an inundation is only to cover a post, or an isolated work; and sometimes, in this case, that useful means of defence may be obtained in a short time, and without much labour.

150. Whatever the object of an inundation may be, its depth requires four or five feet at least; as otherwise, the enemy could easily ford it; thus, it is necessary to ascertain first, whether it can have that depth, and to level the ground in consequence; the fall of the water, and the quantity of it that the stream can supply, in a given time, should also be ascertained.

151. The requisite thickness of the dams depends, 1st. on their height, which must somewhat exceed the intended depth of the inundation, in order that the water, should it happen to swell, may be prevented from rising to the top of the dams, and passing over them. 2dly. On the volume of water which they are to support, and on the rapidity of the stream: Lastly, on the nature of the guns which, according to the importance of the post, the assailants will probably use to batter them and drain off the inundation. With regard to their slopes, they should be regulated according to the rapidity of the current, and the consistence of the earth which serves to construct the dams; the base of the slope down the stream is generally equal to their height, and that of the other slope, from once to twice that height.

152. Since an inundation should not rise above the dams, openings are requisite through which the superfluous water may run off.

153. When both sides of the inundated valley

form a slope, which terminates at the stream, no other issue is requisite for the superfluous water, than the ground *c* beyond the dam, the head of which ought to be then firmly supported, in order to resist the action of the water, which will be great at that place.

154. But when the ground is such as not to afford those natural issues for the superfluous water, artificial ones must be made through the dams.

155. When the stream is small, and the inundation of little importance, it will suffice, in order to let the superfluous water run off, that the top of the dams should be cut in one or two places, according to circumstances, and in such a manner, that the bottoms of the openings thus formed, may be on a level with the intended height of the inundation; the bottoms and sides should be lined with boards firmly fastened to the ground by means of long pickets in the shape of a hook: should there be no boards at hand, fascines may be used. When the inundation has acquired its proper height, the superfluous water will naturally flow away through those openings.

156. But should you propose to raise above its banks a considerable stream, and to form an inundation of some magnitude, then you must use timber sluices with floodgates, which may be shut and opened, as circumstances require; these sluices should be placed near the post or fortification *d*, so

as to be easily defended from it; and they should be constructed in some parts of the dams, which are not opposed to the bed of the stream; for by this means they will require a shorter time to construct them, and a less supply of wood;* besides, the height of the floodgates, and therefore the volume of water which they support, will be smaller; whence their pressure against the grooves which contain them being less, it will be more easy to work them up and down.†

157. Whatever may be the nature of the issues for the superfluous water, their breadth should be determined according to the quantity of water which may be supplied from the stream in its natural state; particular care must be taken to make them sufficiently wide, as the superfluous water, which may then run off through a larger surface, will not rise so high; and in this manner, it will be more easy to keep up the inundation at a proper height. Besides, should sluices be constructed, as the timber-work which they require shall have a smaller height, they will in proportion be less exposed to the cannon of the enemy.

* The reason is obvious, since the height of the sluices will then be smaller.

† Clairac mentions, in his work on Field-fortification, a kind of sluices which he used when repairing the *lines* of La Loutre; they were made of timber, and had their apron three or four feet lower than the top of the dams; five posts with grooves divided their breadth into four equal parts, six feet each.

158. The length of the dams which, in all cases, must be so disposed as to be defended by some part of the fortification *d*, is regulated according to the nature of the banks of the stream, and of the adjacent ground; that is, the dams should be the longer, as the ground is flatter, and particularly when the spot to be inundated has a certain breadth;* should they require a considerable length on that account, it will be proper to cover them with small works *e*, whose extent must be proportionate to the number of troops which defend the main fortification; the dams ought to be constructed in the narrowest parts of the ground to be inundated, and where the depth of the stream is the smallest.

159. It has been explained, No. 150, that the depth of an inundation should not be less than 4 or 5 feet, and when the water cannot rise to that height, holes *f*, 4 or 5 feet deep, and 5 or 6 feet wide should be dug in the ground which you propose to overflow; their number and length may vary according to circumstances, and as these holes, which the first overflowing water fills up, are

* Hence it follows that no proper inundation can be made by the usual means, in a flat ground whose breadth exceeds certain proportions; (see a scheme proposed by Clairac to inundate a flat ground;) a ditch *hi*, parallel to the front line of the fortification *d*, may also be made.

hidden afterwards by the inundation, they render its passage more difficult to the assailants.

160. Sometimes, when the banks of the stream are steep, a small dam *g* is constructed across its bed, in order to increase the depth of the water, and prevent the stream from being fordable.

161. Should the distance of a stream from the main fortification *d* be so great, that it cannot be effectually defended from it with small arms, or, at least, from advanced works which have a safe communication with the fortification, then no other advantages can be derived from the stream than those which it may afford in its natural state; unless, however, you have means to alter its course by making a new bed.

162. When the ditch of a field-work is filled up with water to a depth of 5 or 6 feet, the assailants have particular difficulties in crossing it; wherefore, you should not neglect this additional defence, when you can avail yourself of it.

OF FOUGASSES.

163. Small mines, commonly called *fougasses*, may occasionally afford a very good defence: not on account of the loss of men which the assailants sustain from them, as it is in general inconsiderable; but because they throw them into great con-

fusion and disorder, when they answer their intended purpose. Besides, a soldier is fearful of mines, and does not like to advance on grounds which he suspects to contain them. This means of defence, however, which is so seducing in theory, should be used with consideration, and only in such circumstances as will remove the inconveniencies arising from it in practice.

The first of those inconveniencies is the length of time which the construction of fougasses requires, and the difficulty you may frequently find in procuring the necessary materials; besides, it is not easy, let your precautions be ever so great, to preserve from dampness, at least for a certain time, the powder lodged in the *chamber of the mine* a, pl. 23, fig. 104 and 105, as well as in the *saucisson* that the *auget*, or wooden trough *b* contains, and by means of which the fire is conveyed to the chamber from the interior *c* of the work;* thus you often run the risk of the fougasse failing, when you depend on its effect; in short, as field-works are in general attacked briskly by troops whose rapid movements can not be foreseen, nor regulated by the garrison, as they are in a great measure in permanent fortification, the fire may be set to the mine either too soon or too late, which equally pre-

* The reader knows that the chamber of the mine must be loaded, and the saucisson filled up at the time when the fougasse is constructed.

vents it from producing the desired effect; in my opinion, a disposition of mines, let it be ever so simple, is applicable, in general, only to very important works, which are sufficiently strong to require a regular attack.

After having examined, in a general way, the application of mines to field-works, I refer the reader, for the particulars relative to their construction, &c. to the works of the well known authors who have treated of them with greatest success; such as Belidor, Foissac, de L'Orme, &c.

164. I shall say a few words, however, about a method recommended by many authors who have written on field-fortification, and which is represented by fig. 104; according to this method, the *auget* b is conducted across the ditch, and supported in that direction by pickets *d*, instead of passing underneath the ground, as fig. 105 shows; it is evident, however, that the former disposition, which requires less time and labour than the latter, has the material defect of exposing the saucisson, in its whole length, as well as the pickets which support it, to the cannon of the assailants which may batter them down and destroy them; moreover, should the works have flanks, the auget thus placed would undoubtedly mask their fire, which could not defend the ditch without beating down the saucisson; works without flanks, therefore,

are the only ones to which such disposition may be applicable; but these works are seldom of sufficient importance to require mines.

OF PASSAGES, BRIDGES OF COMMUNICATION, AND GUARD-HOUSES.

165. All isolated field-works, whose gorge is open, indispensably require that it should be secured by palisades, abatis, or by thick branches of trees, unless they are so advantageously situated, that the assailants have no means to turn them; too great precaution cannot be used in ascertaining, whether they can do so or not; for, experience has shewn, in many instances, that by overrating the protection, which works of this kind might receive from the ground, the fire of some collateral works, or a near body of troops, they have been carried by the gorge.

166. When a work is entirely inclosed, as in pl. 23, fig. 106, passages *a* are made through its parapet, the number of which depends on circumstances; they should be placed in such parts of the work as are least exposed to an attack, or which are so disposed as to facilitate the movements which may take place; the requisite breadth of those passages varies according to the importance of the work, and the nature of the arms which you

propose to use in defending it; in a common work, for instance, which is to be defended only with small arms, 5 or 6 feet will suffice for the breadth of the passage, but if the work be important, or should it contain artillery, not less than 9 or 10 feet can properly be allowed, according to the degree of importance of the work, and the nature of the guns which are to be placed therein.*

To prevent the enemy from entering the work through the passages, they are shut up inside by a barrier, a chevaux-de-frize, or by thick branches of trees; behind those obstacles a traverse *f* is constructed, in the form of a parapet, which has a banquette, and whose superior slope is so directed as to allow its fire to defend the avenues of the passages; the length of this traverse should somewhat exceed the breadth of the passages, in order to cover the interior of the works, and its thickness must be regulated according to the greater or less facility which the assailants may have of placing themselves before it; the nature of the attack

* The breadth of the passages ought not to exceed the dimensions which it must have to render the communications convenient; for, the narrower the passages are, the more easy it is to shut and guard them; on that account, the slopes of their sides *b c*, *d e*, should be steep, and even supported by a revetement, when proper materials are at hand, as the steepness of the slopes may thus be augmented, and the width of the passages diminished accordingly.

which the work is intended to resist, ought also to be considered.

167. Many authors recommend constructing a ditch before the traverse, but they have not observed, that it affords no advantage with regard to the actual defence of the work, or even of the passage; besides, it makes it necessary to place the traverse further inside of the work, which is therefore more obstructed by it; lastly, as the interval between the traverse and the parapet in its front is larger, the assailants may enfilade it with greater facility.

168. That the assailants may not enter the work on a sudden, its ditch is not interrupted facing the passages, but small bridges *g* are constructed there across it, which the garrison may easily throw down, in case of an attack; their breadth depends, like that of the passages, on the nature of the work, and on the arms with which it is to be defended; should it be of little importance, and without artillery, bridges 3 or 4 feet wide will suffice; but they require 9 or 10 feet in large works, and particularly when they have guns.

169. Unless a field-work is to stand only for a very few days, it is proper to erect within it, a guard-house, where part of the men may be sheltered from the inclemency of the weather, and its size should be proportioned to the strength of the ordinary guard of the work. With regard to the

method of constructing it, that depends on the season, and on the requisite duration of the work: if it be short, a kind of hut, slightly made with turf, branches, straw, broom, furze, or with any other such materials, will suffice; but should it be designed to last for some weeks, the construction of it will require more care, and you must render it as solid and convenient as the materials which you have at hand may allow; lastly, when a work is to stand for a whole campaign, or during the winter quarters, &c., then the guard-house ought to be built with timber, mortar made of mud and straw or hay, &c.

170. As the traverses and guard-houses of which I have been speaking, occupy a certain space inside of field-works, it is proper, after fixing the dimensions of the redoubt conformably to the rules which I have given, Nos. 18 and 20, that you should make an allowance proportionate to the obstruction which the traverses and guard-house may occasion in the work, and which depends on its size; I have not mentioned this particular when I explained the rules, in order not to anticipate my subject.

OF SIMPLE GLACIS.

171. A glacis *a b*, pl. 24, fig. 107, which has no *covert way* behind it, is called a *simple glacis*.

Glacis of this kind afford many advantages;

wherefore, one should be constructed, when possible, in front of all field-works from which a certain resistance is required; first, they raise the edge of the counterscarp *a d*, and so increase the depth of the ditch, without it being necessary that its bottom *c d* should be lower relatively to the crest *e* of the parapet of the work; secondly, they cover the escarp *f c* to a greater height, whence the palisades *g*, which are placed in its slope, and those upon the berm, should there be any, are less exposed. Thirdly, they are protected by the fire of the work before which they stand, and require no other troops for their defence than its garrison; fourthly, they allow of giving a smaller inclination to the superior slope *e f* of the parapet; for, as the assailants, when ascending the glacis, rise higher and higher in proportion as they approach its crest, it evidently follows that they are more and more exposed to our fire; lastly, a simple glacis does not require that the work behind it should have a greater command than that which field-works commonly have;* and I shall soon demonstrate that glacis which precede a covert-way, are far from possessing most of those advantages.

172. I desire the reader to recollect what has been said in No. 91; namely, that a foot-soldier,

* The reason is, that a simple glacis is not to cover any troops, and therefore its height may be regulated in all cases, according to the command of the work before which it stands.

of common size may fire in a horizontal direction about 4 feet 6 inches higher than the ground on which he stands; and that the top of the parapet of a work which is attacked, is soon damaged and lowered by the enemy's shot; whence I conclude, that the crest of a glacis in general, must be 5 feet lower, at least, than the interior crest of the parapet of the work before which it stands.*

173. When a work, fig. 108, before which a simple glacis *a b* is constructed, has a sufficient command to allow the crest *a* of the latter to be 4 feet 6 inches, or 5 feet higher than the horizontal ground, a small berm *c* may be left between the

* Clairac, Bousmard, and most engineers, allow a less command to the work over the glacis; nay, we find a profile in Bousmard's *Essai Général de Fortification*, where that command is not more than 3 feet, but I do not hesitate in declaring, that the glacis, in this case, is more prejudicial than useful; and that it weakens the defence which it is intended to strengthen; since from its crest, the assailants will plunge their fire into the work.

Indeed, not less than 5 feet should be allowed for the command of a field-work over any other in its front, whose distance from it does not exceed the common range of a musket; this dimension may appear exaggerated to some readers, as a less command is frequently given to permanent works; but I shall observe, that as field-works are in general attacked briskly and openly, no *lodgment* is requisite; so that the assailants, after carrying a work which precedes another, will stand on the top of the parapet of the former, where they are to remain for a short time, and without being much more exposed than in its terreplein, if from it they can plunge their fire into the last work.

counterscarp and the glacis, and a row of palisades *d* be planted there vertically, the points of which should not rise higher than 8 or 9 inches above the crest of the glacis; in this case, they will not obstruct the fire of the work, nor be much exposed to be destroyed by the direct fire of the assailants.*

174. A certain breadth may also be allowed to the berm *c*, and thick branches of trees *o* be placed either upright along the interior slope of the glacis, as in fig. 110, or horizontally across the berm, as in fig. 109, with a row of palisades *d;* this last method is preferable to the former, because the branches are better concealed from the enemy, who can scarcely ruin them with his cannon, and is obliged to destroy them by some other means, before he can descend into the ditch.

OF COVERT-WAYS.

175. Very trifling, indeed, is the additional strength which in most circumstances field-works can receive from a covert-way *h* in their front,

* These palisades, which the interior slope of the glacis keeps at a certain distance from its crest, defend the counterscarp well, and the enemy, who cannot get over them without great difficulties, and without running the risk of not being able to reascend upon the glacis, in case he should be repelled, must destroy part of them before he can venture to descend into the ditch.

pl. 23 and 24, fig. 106 and 111; for, as they are in general attacked briskly, and on several points at once, No. 1, it follows, that should the troops, which are placed in the covert-way, attempt to defend it with obstinacy, they would be greatly exposed to be taken in reverse, and driven into the ditch; then they must withdraw from it, before the assailants are near, and after a slight resistance, which is, of course, of little effect with regard to the defence of the main work.

176. Let us now consider the inconveniencies which a covert-way occasions; first, it often requires that the interior surface of the main work should be greater; for then it ought to be sufficiently capacious to contain, not only the garrison, but the troops requisite for defending the covert-way, since they must retreat into the work, when unable to withstand any longer the enemy's attacks, as it has been explained.* Secondly, should the crest *a* of the glacis, fig. 111, be less elevated than 6 feet, above the horizontal ground, the men in the covert-way *h* would not be covered, No. 91; and as the command which the main work must have over the glacis, should not be less

* Should not the interior surface of the main work be augmented, it would frequently be too small for the number of the troops, which therefore would be cramped in their movements, and undoubtedly thrown into confusion; besides, the loss of men would be greater, on account of the troops being crowded.

than from 5 to 6 feet, it follows that its parapet requires the uncommon height of about 12 feet. Indeed, many engineers recommend sinking the covert-way *h*, as in fig. 112, pl. 25, in order to diminish the elevation of the crest of the glacis above the horizontal ground, and therefore, the height of the parapet of the main work; but it is evident from what has been explained in No. 92, that little can be gained by this method, which, in the case before us, has also the defect of lowering the edge *c* of the counterscarp *c d;* for, if we suppose that the covert-way is sunk 2 feet, and that the elevation of the crest *a* of the glacis above the horizontal ground is only 4 feet, even the terre-plein of the covert-way will then be exposed to the plunging fire of the assailants; now, let it be admitted that the covert-way is sunk only 1 foot, and that the crest of the glacis is 5 feet higher than the horizontal ground; in this case, I own, the assailants will not be able to plunge their fire into the covert-way, but the men on the banquettes will scarcely be secured from their horizontal fire, and particularly if we suppose, as we may rightly do, that soon after the beginning of the attack, the crest of the glacis will be damaged by the enemy's shot; thus even supposing that the covert-way is sunk, yet not less than from 10 to 11 feet is requisite for the height of the parapet of the main work; nay, the covert-way is then scarcely inhabitable, and in-

deed you ought not to rely on its defence, unless the crest of the glacis can have a command of 6 feet at least above the country.*

177. The great command required for a field-work, which has a covert-way in its front, gives rise to another material inconveniency, when the work has flanks; namely, their fire cannot well defend the ditch of the flanked parts, unless the lines of defence are very long, or the inclination of the superior slope of the parapet very great, the defects of which I have demonstrated; besides, whenever a covert-way is constructed before a work, its terre-plein must be defended from it, as otherwise the assailants would find a cover therein; and therefore, a covert-way requires, in all cases,

* Most engineers, however, without excepting Vauban, Clairac, &c. allow a much smaller command to the glacis over the country; but then the defence which the covert-way can afford is weak beyond measure, and does not compensate for the loss of time, the increase of labour, and the other inconveniences arising from its construction; therefore it is preferable not to make any.

Noizé de St. Paul proposes to construct traverses *i*, pl. 23, fig. 106, and to proportion their thickness to that of the parapet of the work; he is perfectly right, and I scarcely conceive how the covert-way could be tenable, particularly when the glacis has no great command over the country, should the troops not be protected by such traverses against the reverse and enfilading fire of the assailants; besides, the places of arms, and the communication from the covert-way to the work are safer by their means.

that the superior slope of the parapet of the work behind it should be greater than is requisite when a simple glacis is made.

178. I shall conclude with saying, that covert-ways should be seldom constructed in the field, as they are only applicable to very important works so calculated as not to be exposed to a brisk attack, and which may be timely supported from without by a body of troops sufficiently near to throw in reinforcements and withdraw them, according to circumstances.

179. It has been proposed to construct simple glacis with places of arms *m*, as in pl. 23, fig. 106; this method undoubtedly affords certain advantages; first, as a small number of men is requisite for the defence of the places of arms *m*, it may be supplied from the garrison of the main work, whose interior surface, therefore, need not be augmented: secondly, the fire of the places of arms protects the saliants, and when they are placed in front of the passages *a*, they cover them, secure the bridges *g*, and prevent surprises; it is to be observed, however, that glacis of this kind require, as well as covert-ways, that the height of the parapet of the main work should be very great, since its command over the places of arms must be the same; the terre-plein of the places of arms, too, ought to be defended from the main work, as otherwise, it would afford a place of security to

the assailants, after they have carried them, and therefore, the slope of the parapet requires as much inclination as it does when a common covert-way is constructed; hence it is obvious, that, in general, simple glacis with places of arms are not more applicable to field-works than common covert-ways. When expedition in constructing them is required, only the parts *o n* and *o p* of the glacis which form the faces of the places of arms may have a sufficient command to cover the troops which defend them, No. 176, and the remaining parts *p q* and *q r* may be raised only to such a height as is requisite to render the fire of the main work effective.

OF AVANT GLACIS.

180. Avant glacis, *a b*, pl. 25, fig. 113 and 114, are intended to cover obstacles, such as palisades, chevaux-de-frize, &c. which may impede the enemy's approach; but this additional means of defence, which many engineers recommend, is seldom applicable to field-works, and particularly when they are preceded by a covert-way, or by a simple glacis with places of arms, as I shall demonstrate.

First, Let us suppose that an avant glacis *a b*, fig. 113, is constructed in front of a common simple glacis *c d;* as the guns which are generally

used for field service may fire in a horizontal direction from 3 to 4 feet higher than the ground upon which they stand, it follows that should the crest *a* of the avant glacis be less elevated than 4 feet, or thereabout, above the horizon, the obstacles *e* would be exposed to the plunging fire of the artillery, and would be soon destroyed; in as much as palisades, abatis, and chevaux-de-frize will be seen by the enemy, unless the crest *a* of the avant glacis is 4 feet 6 inches higher, at least, than the ground on which they are placed. On the other hand, it is evident, from what has been explained, No. 93, that the command of the parapet, *f g* of the main work of the crest of the avant glacis must be 6 feet, at least,* and therefore, the parapet requires the uncommon height of 10 feet.

181. If we now suppose that the avant glacis *a b*, fig. 114, precedes a covert-way *c*, as the command of the latter over the former must be from 5 to 6 feet, No. 172, note*, not less than 9 or 10 feet should be allowed for the elevation of the crest

* It is proper that the command of the main work over the avant glacis *a b*, should be somewhat greater than its command over the glacis *c d;* for, as the former is more distant from it than the latter, it follows that the shot fired from its crest *a*, and which graze the interior crest *f* of the parapet of the main work, pass at a smaller height over the banquettes which are in their direction; I shall observe, however, that no great difference is required in those two commands, and particularly, as the glacis *c d*, and avant glacis *a b*, are not intended to cover any troops.

d of the glacis *d e* above the horizontal ground; and therefore, the parapet of the main work requires, in this case, the immense height of 14 feet, at least, since its command over the covert-way should not be less than that of the covert-way over the avant glacis.

182. Many engineers recommend to cut the ground sloping, as *a b*, in pl. 26, fig. 115, and 116, so that the obstacles *c* being placed below the horizontal ground, the avant glacis, and therefore the parapet of the work may be less elevated above it; but those engineers have probably not observed, that by this scheme, the obstacles are only secured from the front fire of the assailants, and that they are still exposed to be battered in reverse and enfiladed by the artillery which, on account of the insufficient elevation of the avant glacis above the horizontal ground, may plunge its fire over it and soon destroy them.*

183. Let us conclude that avant glacis may be occasionally used before simple glacis, as in fig. 113, pl. 25, when the command of the main work

* It has been objected to me, by several engineers, that although the enemy may not take a long time to destroy the obstacles *c*, yet they will retard, to a certain degree, his approach to the main work; this I admit: but I deny that the slight advantage thus gained can compensate for the loss of time, additional labour, and the other inconveniencies arising from such avant glacis.

over the country is about 10 feet; but that they are very seldom applicable to field-works which have a covert-way in their front, as they will not answer any useful purpose, unless those works may have a command which is suitable to permanent rather than to field-fortification.

184. I shall now explain the method of regulating the slope of the glacis.

It is considered as an axiom in permanent fortification, that no greater inclination should be given to a glacis, than that which, being produced, will meet the interior crest of the parapet of the work in front of which the glacis is constructed; but as field-works have in general a small relief, and because you cannot always command a sufficient time to allow a proper length to the glacis, you are sometimes compelled to deviate from that rule, and to make it steeper;* in this case, draw the indefinite line $e f$, pl. 24, fig. 110, passing through the interior crest e of the parapet, and the crest a of the glacis; and take a point d on this line, 2 or 3 feet at most† higher than the horizon-

* The reader may easily conceive that the remblai of a glacis, and therefore the requisite time for its construction are in proportion to its length, the elevation of its crest above the horizontal ground being the same.

† The point d should in no instance be elevated more than 3 feet above the horizontal ground, as otherwise the glacis would mask the fire of the work and cover the assailants.

tal ground; from *d* let fall a perpendicular *d b* to the horizontal ground, and the point *b* will determine the foot of the glacis.

185. I have said that an avant glacis may be occasionally constructed in front of a simple glacis, and now observe that the slope of the former must be regulated according to the same principles as that of the latter.

OF REDOUBTS.

When a field-work, whose gorge is secure, covers any communication *g*, pl. 7 and 8, fig. 31, 32, &c. through which the garrison can retreat, another work *m*, called *redoubt*,* is sometimes constructed within it, which, when properly disposed, affords several advantages; first, it increases the strength of the work by which it is encompassed, since it ought to be so formed as to defend its approach, particularly in the most exposed points, and to protect the passages through its parapet: secondly, the whole interior of the main work must be exposed to the fire of the redoubt, wherefore the assailants have greater difficulties in establishing themselves within the former: and as the communication *g* is also covered by the latter, it

* I have already mentioned these works, as being occasionally applied to têtes de pont.

follows that the troops which defend the main work, and can retreat more safely, should they be compelled to withdraw from it, have greater confidence, and are more inclined to resist to the last.*

The requisite extent of a redoubt chiefly depends on the importance of the main work, and on the nature of the communication which it covers; with regard to its form, it is evident from what has been explained in the preceding number, that it ought to be regulated by that of the main work;† I observe likewise, that as the parapet of the redoubt is not so immediately exposed to the fire of the assailants as that of the main work, it requires less thickness than the latter, but its height should be greater, since the redoubt must command the main work. (See No. 172 and its note.*)

It has been proposed by several authors to construct a redoubt inside of inclosed and isolated

* When the approach to the main work is difficult, and the communication easy to protect, a simple *tambour* made with timber work, palisades, &c. is frequently used, instead of a redoubt; should the access to the main work, on the contrary, be easy, and the communication difficult to protect, a tambour of this sort may be made, inside of the redoubt, in order to procure an additional defence which may better secure the retreat of the troops.

† The form of the tambour of which I have been speaking, should also be regulated by that of the main work, or of the redoubt, when it is constructed within it.

works in order that their garrison, as it cannot retreat, nor receive assistance, may stand a second attack in the former, after being compelled to abandon the latter, or capitulate on honourable terms.* Such method, however, is in general defective, and it is scarcely applicable to very large works which may be quickly supported from without; for it requires that the redoubt should be sufficiently capacious to contain all the men who have escaped the dangers of the first attack; and as it is found from experience, that in general only $\frac{1}{3}$, or thereabout, of the original strength of the garrison is disabled, it follows that the redoubt must have a great extent, whence it may obstruct the main work; besides, a quantity of stores of all sorts should be laid in, which can scarcely be procured in the field; and lastly, accommodations are requisite for the soldiers, which you seldom have time to prepare.†

When a guard-house is constructed, No. 169,

* In this case the redoubt should be entirely surrounded by a parapet, as well as the work in which it is placed.

† Those inconveniencies do not take place, when the work, inside of which a redoubt is constructed, covers a communication which allows the garrison to retreat; for in this case, no greater number of men should be left in the redoubt, than that which is necessary to prevent the assailants from establishing themselves in the main work, before the rest of the troops have retreated; the garrison, besides, can receive the necessary supplies, or withdraw from the work, should they be destitute.

for the ordinary guard of a field-work, which is to stand for a certain time, its inclosure, which then requires as much solidity as possible, is frequently pierced with loop-holes, in order that the men, should they be surprised, may retreat to the guard-house and give intelligence of their being attacked, by firing through the loop-holes.

FURTHER CONSIDERATIONS ON CREMAILLERES.

It has been said in No. 26, that cremaillères might prove very useful in defending the saliants of works which have no flanks; this ingenious contrivance, however, is not applicable to field-works in all circumstances, and even when it may be applied, it must be circumscribed by certain limits, as I shall demonstrate.

First, cremaillères require much time and considerable labour; not only on account of the difficulties which attend their construction, but because the thickness of the parapet to which they are adapted, and the breadth of the banquette must be greater; they have also the inconveniency of diminishing the interior surface of the work, besides the following: let *a b c*, fig. 117, pl. 26, represent the saliant of a work, it is evident, that should a cremaillère *d e f g*, &c. be adapted to it,

the parapet will be higher at the vertices *e*, *g*, &c. of the re-entering angles formed by the *teeth*, *d e f*, *f g h*, &c. of the cremaillère, than at those *f* and *h* of the saliant angles *e f g*, &c.; and that its greater elevation at the former points, will be in proportion to the inclination of its superior slope, and to the projection of the cremaillère inside of the work;* for instance, if the breadth *a e* of the parapet, (the cremaillère not included) is 6 feet, as represented by fig. 118, the inclination of its superior slope *a b* 18 inches, or 3 inches per foot, and the projection *c a* of the cremaillère 4 feet, the parapet will be 1 foot higher at *c* than at *a*, since *c a* is $\frac{2}{3}$ of *a e*, and the inclination of the superior slope uniform. Now, let us suppose that the parapet at *a* is 4 feet higher than the banquette, conformably to the dimension recommended in No. 119,† then its elevation at *c*, above the banquette, will be 5 feet, and the man there placed will not be able to fire in a proper direction;‡ if, in order to avoid

* This projection is represented by the *flèche e i* of the *tooth*, *d e f*, of the cremaillère.

† I here suppose that the point *a*, fig. 118, represents the point *f*, fig. 117; which is not correct: but since it corresponds to the point *i*, it is evident that this supposition may be allowed for the sake of demonstration, as the height of the parapet at *i* and *f* is the same.

‡ It is scarcely necessary to observe, that the point *c*, fig. 118, represents the point *e*, fig. 117.

that defect, the banquette should be raised to 4 feet from the point *c*, in this case, the height of the parapet above it at *a*, would be only 3 feet, and the man there would not be covered. Indeed, the banquette might be raised at *e*, fig. 117, and go sloping from *e* to *f*, so as to be 4 feet lower in those two points than the interior crest of the parapet; but another inconveniency would arise from it: namely, the man at *e* would stand 1 foot higher than the man at *f*, and he would be exposed to the enfilading fire which might pass over the saliant angle *e f g*.

The defect which cremailleres have, of raising the parapet at the points *e g*, &c. fig. 117, is undoubtedly material, and particularly when they are adapted to field-works, as the superior slope of the parapets of such works requires a greater inclination, in general, than that of permanent works. This defect, however, may be considerably diminished by reducing that inclination, allowing a proper projection to the cremailleres, and, when possible, by constructing a glacis, which the assailants cannot ascend without being exposed to the fire of the work. For instance, let us suppose that the breadth of the parapet, fig. 118, remaining 6 feet, its superior slope, *a b*, is raised to *a g*, with an inclination of only 12 inches, or 2 inches per foot; and that the projection *a f* of the cremaillere is 2

$\frac{1}{70}$ feet;* in this case the height of the parapet at *f*, above the banquette, will be little more than 4 feet 4 inches, admitting that it is 4 feet at *a;* and although the former elevation is great, No. 119, yet the inconveniencies arising from it will be considerably diminished, and particularly if a glacis *d* can be constructed, by placing at *f* the tallest and most steady men.

Should the re-entering angles *a b c*, &c. which the teeth of the cremailleres make, be acute, as in pl. 27, fig. 119, the shot would be directed inside of the work, as is shewn by the lines of fire; and if they were obtuse, as in fig. 120, the fire would diverge from the capital which it is intended to de-

* Some readers may think this projection too small, as, from want of reflection, most authors erroneously recommend 4, 5, and even 6 feet; but I observe, first, that since the defects of cremailleres augment in proportion as their projection inside of the work is greater, this projection should be diminished as much as possible, without preventing their effect. Secondly, that the faces *c f*, *g h*, &c. of the teeth, where the men are placed to defend the saliant, are 3 feet, when the flèche *e i* is $2\frac{1}{10}$ feet; and that their length is sufficient to afford room for one man, notwithstanding the diminution occasioned by the interior slope of the parapet; for, as this slope should not in general exceed 1 foot, No. 107, 2 feet will remain to the man, who, as he is not impeded in his movements by any neighbour, may act with ease; especially as he may lean towards the interior slope. Lastly, since cremailleres have some defects, as has been demonstrated, even when their projection is only $2\frac{1}{10}$ feet, what would be the case, supposing it to be 4, 5, or 6 feet?

fend: (see the lines of fire;) therefore, those angles must be right ones, which would give rise to great inconveniences, should not the saliant to which a cremaillère is adapted be also a right angle; for if we suppose it acute, as *a b c*, fig. 121, the base *d e* of the teeth, and their flêche *f g* will be longer,* wherefore, a smaller number of them can be adapted to a given length of parapet; the cremaillère will also project more inside of the work, and increase the height of the parapet in proportion, at the angles *f*, *h*, &c. Should the saliant, on the contrary, be obtuse, as *a b c*, fig. 122, the base *d e* will undoubtedly become shorter, and therefore more teeth may be constructed along the same length of parapet; but in this case, as well as in the former, difficulties will occur in tracing the cremaillère; for let the saliant be either acute or obtuse, fig. 121 and 122, the sides *f e*, *h i*, of the teeth, from which it is defended, must invariably be 3 feet, or thereabout, as I have explained; and since in both cases, the other sides *f d*, *h e*, &c. and the base *d e* vary according to the opening of the saliant, it follows that should a cremaillère be adapted to an acute or an obtuse saliant, you ought, first, to find by trial, the length which the base

* The reason is, that the sides *f e*, *h i*, &c. where the fuzileers are placed who defend the saliant, should not be smaller than 3 feet, since according to calculation a shorter length would not allow a man to act with ease.

d e must have, in order that the sides *f e*, *h i*, &c. may be 3 feet, and then carry this length along the parapet, so as to determine the points *d*, *e*, *i*, &c. from which the lines *f d*, *h e* parallel to the capital, and those *f e*, *h i*, perpendicular to it, must be drawn.

It is not the same when the saliant forms a right angle, as *a b c*, fig. 123; for, in this case, the triangle *d f e* is isosceles, since the side *f d* is equal to the side *f e;* and therefore, those sides will have a length of 3 feet, when the base *d e* is $4\frac{1}{5}$ feet; thus it will suffice, in order to trace the cremaillères, to set off $4\frac{1}{5}$ feet from *d* to *e*, from *e* to *i*, &c. and to construct on each of the lines *d e*, *e i*, &c. an isosceles triangle whose sides *f d* and *f e* will be equal to 3 feet.

As cremaillères, by the nature of their construction, give three different directions to the fire of the parapet, it has been thought in former times, (and many engineers may still believe) that by their means, the faces and saliants of a work can be properly defended at the same time; if we suppose, however, that the base *a b* of the teeth, fig. 124, is $4\frac{1}{5}$ feet, and that the sides *c d* and *c e* are 3 feet, conformably to the dimensions which I have recommended, it will be impossible to place a man at *d* and at *e*, should there be one at *f* and at *g*, since the small length of *c d* and *c e* will not allow it; thus the faces of the work will be de-

fended only by the fire of the men at *c*, *h*, &c.; and as those points are $4\frac{1}{5}$ feet distant from each other, it follows that the quantity of fire applied to the defence of the faces will be much less than it would be without cremaillères,* and that therefore the defence will be weak.

Now, if in order to have sufficient room for one man at *d* and at *e*, and for another at *f* and at *g*, the length of the sides *c d* and *c e* should be increased, then the projection of the cremaillère will be too great; for in this case, no smaller length than 4 feet, at least, should be given to *c d* and *c e*; and I have pointed out the inconveniences arising from such length.

Moreover, even supposing the sides *c d* and *c e* to be 4 feet, the men at *g*, *c* and *f*, whose guns cross over each other, will not be able to fire conveniently, and in good order; nay, as the common length of a musket, the bayonet included, is about 5 feet 10 inches, and that of the sides *c d* and *c e* only 4 feet, the bayonets of the men at *g* and *i*, and the gun of the man at *e* will meet one another: lastly, this gun stands in the direction where the fuzileers at *g* and *i* fire; therefore it is exposed to be shattered to pieces by their shot,

* The reason is obvious, since it has been said in No. 6, that in general the parapet should be manned at the rate of 2 men per toise. Whereas, in the case before us, the soldiers who defend the faces would be $4\frac{1}{5}$ feet distant from each other.

and a great confusion must undoubtedly take place.*

It follows from the preceding observations, that the faces and saliants of a work, cannot be properly defended at the same time, by means of cremaillères, which, therefore, should not be adapted to the whole parapet of a work, and particularly as defects would arise from it in some other respects; but a few teeth may be very usefully applied to the defence of exposed and unprotected saliants, and even the faces will gain a greater quantity of fire by this disposition, in case the attack should be directed against them, as the men may be then placed at the angles *d*, *c* and *e*,† where they stand at no greater distance asunder than about 2 feet, supposing, however, the base *a b* of the teeth to be $4\frac{1}{5}$ feet.

* It would be still worse, should the length of the sides *c d* and *c c* be more than 4 feet, in order to place two or three men along them, besides those at the angles *d*, *c*, *e*, *h*, &c. as many authors recommend; for in this case, more guns would cross each other, and be exposed to be shattered.

† I here suppose that the garrison of the work is sufficiently strong to allow this disposition; should it not, as the men could only be placed at the angles *d*, *e*, &c. they would be too distant from each other, and the defence of the faces would undoubtedly be impaired.

CHAPTER V.

OF DEFILEMENT AND TRAVERSES.

186. When you are compelled by circumstances to construct a work at a smaller distance from a height that commands it, than the reach of the arms with which it may be attacked,* it becomes necessary to hide its interior as much as possible, in order to secure it from the plunging fire of the enemy; and this object may be obtained, chiefly by giving a proper disposition to the tracing of the work: defilement and traverses may also be used.

187. The general principle to be observed, in applying the first of those means, is to dispose the work in such a manner, that the points where the prolongations of its sides would meet the height, will be as distant from it as possible, without the work ceasing to answer the purpose for which it is raised.

For instance, let us suppose that a work, whose gorge is open, should be constructed near a height R, which commands it in front, plate 27, fig. 125; in this case, it would be improper, could it be

* I have explained before, that all field-works are not exposed to be attacked with cannon, since the importance of some of them may be so small, as to make it improbable that the assailants will bring artillery against them.

avoided, to dispose the work like those, *f b h*, *d b g*, *e b f c g*, and *e b m c g;* for it is evident, that their sides produced meet the height R at a short distance, and that they are exposed to the reverse and enfilading fire which the assailants may keep against them from that height; it is also evident, that the straight line *a b c*, parallel or nearly so to the height, is the safest tracing, and that after this, the one whose figure is nearest to it, the tracing *a b c d*, for instance, must be preferred.

188. Should a work be intended to defend the opening of a valley A, fig. 126, the figure *a b c d*, the side *b c* of which is directly opposite to the valley, and whose sides *a b* and *c d* are parallel to the heights C and D, or nearly so, would be more suitable to it, than that *a b m c d*, whose sides *b m* and *m o* regard the valley less directly, and are exposed, besides, to be taken in reverse and enfiladed, as may be seen from the figure: or than the figure *e f g h i*, whose sides, which only defend the passages between them and the heights, may also be enfiladed.

189. With regard to the enclosed works represented by fig. 127, plate 28, and which are commanded in front by the height A, it is obvious that the disposition of those *a*, *b*, and *c*, exposes all their sides to be enfiladed, or taken in reverse; whereas the works *d* and *e* have at least a part of

their figure parallel, or nearly so, to the height; and these works, therefore, can make a better defence than the former.

190. If we suppose that an enclosed work which is commanded by the heights A and B, fig. 128, is to defend the opening of a valley C, in this case the figure *a b c d*, of which the side *b c* regards the valley, and those *a b* and *d c* have their prolongations directed towards it, is far preferable to the figures *e f g h d* and *i k n m*, as all their sides are enfiladed from the heights A and B.

191. As the configuration of the heights near the work, and their situation in its respect, may vary without end, and since its tracing should be determined according to the various circumstances which may occur, it is impossible to give particular rules for every case; therefore, I shall confine myself to those examples, as they will suffice to show to the reader how the general principle, which I have laid down, with regard to the requisite disposition of a commanded work, may be applied. I shall now explain the method of *defiling* field-works.

192. A work *a e b*, plate 28, fig. 129, which is commanded by a height X, is said to be *defiled*, when the interior crest *c o d* of its parapet is placed in an inclined plane *c h d* so elevated above the horizontal ground at the points *c* and *d*, (which are the parts of the work the most distant from

the height, and therefore the lowest,) that the parapet may have a proper command, in those points, over the horizontal surrounding ground; this plane, which is called *plane of defilement*, should rise gradually towards *g*, which I suppose to be the most commanding point of the height, and pass to a greater elevation above it, than the height to which the assailants can fire horizontally; lastly, the banquette, terre-plein, &c. are generally placed in planes parallel to the plane of defilement,* and the operation altogether is called *defilement*.

193. Should the work *a e b* be not more distant than 150 toises from the height X, it will be requisite to secure it from the fire of musketry,†

* When no inconvenience arises from the natural ground upon which the work is constructed forming its terre-plein, this method should be preferred, in order to avoid the remblais and deblais, which in some cases may be great, and require a considerable additional labour.

† Even supposing that a work is only intended to resist musket shot, it is proper to defile it when its distance, from the commanding height, does not exceed 150 toises; for it has been explained, that although the range of a common musket should not in general be reckoned more than 100 toises, in order to depend on the effect of musketry fire, yet experience proves that a man may be struck by a ball as far as 150 toises. With regard to field-works which may be attacked with cannon, they require to be defiled when they are less distant than 500 and even 600 toises from the height which commands them; the reason is,

and the elevation of the plane of defilement *c h d* above the point *g* must not be less, in this case, than 7 feet, 6 inches, No. 95; but 4 feet will suffice, when the distance of the work from the height is greater than 150 toises; for then, you are only exposed to the fire of artillery, and even the field-pieces which have the highest carriages, cannot fire horizontally to a greater height than between 3 and 4 feet: it is scarcely necessary to observe, that it is useless to defile a work which is not intended to resist cannon shot, when its distance from the commanding height exceeds 150 toises.

194. Could you command as much time, and the same abundance of means, in defiling field-works, as you can in permanent works, you should undoubtedly determine the planes of defilement of the former by the same methodical processes as those of the latter; namely, you should survey the ground, level it, &c. but operations more simple, and especially which can be performed with greater rapidity, are required in the field; wherefore you are often compelled to defile field-works by means which I own are founded on the same theory as

that although the range of field-pieces should not in general be reckoned more than 250 toises, in order that you may depend on their execution, yet they may produce some effect from a distance of 500 or 600 toises, when they are numerous, well-served, and fired against troops collected in a mass.

those used with regard to permanent works, but which differ from them in practice. I shall explain the methods which in my opinion are the most convenient and the least uncertain.

195. First, let us suppose that a work, *a e b*, whose gorge *a b* is open, plate 28, fig. 129, should be defiled from the height X which commands it in front, and is nearer to it than 150 toises; whence it evidently follows, that its interior must be covered from the fire of musketry, even admitting that it may be attacked with cannon: first, determine its requisite relief at the extremities *a* and *b* of its faces, that it may have a sufficient command over the horizontal surrounding ground; plant at *a* and *b* staves *a c*, *b d*, whose height should be equal to that which the interior crest of the parapet must have at those points; next, place a staff *e f* at the saliant *e* of the work, and another staff *g h* at the point *g*, which you think to be the most commanding point of the height; the head *h* of this staff ought to be 7 feet 6 inches higher than the point *g*, No. 193, since we here suppose that the work must be defiled from the file of musketry; but were you only exposed to cannon, the height of the staff *g h*, above the point *g*, should not be greater than four feet.

After these preliminary dispositions, look for a point *i*, which should be at the same time in the direction of the staves *a c*, *b d*, and of those *e f* and

g h; whence it appears that its situation depends on that of the point *g* relatively to the work, and that it may lay, either between the staves *a c* and *b d*, as in this example, or without them, according as the point *g* stands more or less to the right or left of the sides *a e* and *b e:* fix a staff *i m* at the point *i*, and after placing yourself near the staff *a c*, or that *b d*, according to the situation of the staff *i m*, direct a visual ray, along the heads of the two former staves, and cutting the latter in a point *n:* through which point and the head of the staff *g h*, direct likewise a visual ray cutting in *o* the staff *e f;* this point *o* will fix the height of the interior crest of the parapet at the saliant; lastly, place the banquette, and the terre-plein if necessary, No. 192, (note*) in planes parallel to the plane of defilement *c h d*, so that the plane of the banquette be four feet below it; and that of the terre-plein six feet at least; the work will then be defiled.

196. The determination of the point *g*, from the elevation and situation of which the disposition of the plane of defilement depends, as has been seen, requires an uncommon degree of attention from the engineer, and particularly, when he fixes it only by the eye;* for then, he is more exposed to

* It rarely happens in the field, that you have a sufficient time to survey and level the ground, conformably to the method used

errors, the rectifying of which requires much time, and increases the labour considerably; in order to guard the reader against the principal cause of those which may be committed, I shall observe that the most elevated point of a height, with regard to the horizontal ground, is not always the point from which the work that is commanded should be defiled; for, let us suppose that the work X, fig. 130, must be defiled from the height S; although the point *a* of this height is more elevated than the point *b*, with regard to the horizontal ground *c d*, yet it would be improper, in this case, to determine the plane of defilement *e f* by means of the former point, and it is the latter which should be used in regulating it; as otherwise, *the plane of site g a*,* which according to rule must pass over every point of the height, would pass below the point *b*, and the assailants could plunge their fire into the work from this point,† as shown by the dotted line *h i*, although

in defiling permanent works; wherefore you are most frequently obliged to determine only by the eye the most commanding points of a height.

* The plane of site is that in which the terre-plein of the work is placed.

† The reason is, that as the point *b* is less distant from the work than the point *a*, it is nearer to the plane of defilement *e f*; and, therefore, the assailants at the former point may see above that plane, as is shown by the line *b h* equal to the height of the staff *a e*.

they cannot do it from the point *a*, which is higher.

197. In order to ascertain whether a work is well defiled, visual rays should be successively directed from all the staves placed at the angles which are formed by the interior crest of the parapet, to the points which appear the most commanding; and the staves should be raised or lowered, according to circumstances, till it is found that the plane of defilement is well established; the following method is also very simple and easy, and I should prefer it to any other:

Fix cords to the heads *c*, *o*, *d*, fig. 129, of the staves which regulate the relief of the interior crest of the parapet, and place staves *p q*, *r s*, of a requisite height, No. 193, at the different points of the ground which appear to be the most commanding after the point *g*; from behind the lower cord *c d*, direct visual rays tangential to the other cords *c o*, *d o*, and produce them to the staves *p q*, and *r s*; if those rays do not cut them, it is a proof that the work is properly defiled; but should the contrary happen, the plane of defilement must

The reader will undoubtedly perceive that by using the point *b*, instead of the point *a*, to determine the plane of defilement, it rises more above the latter; and as its inclination is thus greater, it becomes necessary to lower in proportion the terre-plein of the work.

be rectified before you begin to construct the work.

198. This is another expeditious method of determining the plane of defilement of a work, pl. 29, fig. 131, which is commanded in front, and whose gorge is open: the same as in the method explained in No. 195, and which is represented by fig. 129, pl. 28, plant staves, *a b*, *c d*, at the extremities *a* and *c* of that gorge, whose height should be equal to that of the interior crest of the parapet at those points; place other staves, *e f*, *g h*, and *i k*, at such points of the height as appear to be the most commanding, and make their height equal to 7 feet 6 inches, or to 4 feet, according as the work may be attacked with small arms or cannon, No. 193; join by a cord the heads *b* and *d* of the staves *a b*, *c d;* at a small distance behind which, two other staves, *l m*, *n o*, should be planted in such a manner that a line drawn through their heads would be parallel to the cord *b d:* move about a long ruler or a cord, *p q*, along the staves *l m* and *n o*, till it be in the direction of an inclined plane, tangential to the cord *b d*, and which being produced would pass above the staves *e f*, *g h*, &c.; then fix the long ruler or the cord *p q*, and from behind it direct visual rays tangential to it and to the cord *b d;* the points *r*, *s*, *t*, where those rays produced meet the staves placed at the angles of the work, will

regulate there the elevation of the interior crest of the parapet.

199. I have hitherto supposed that the most commanding points were in front of the work, in which case the plane of defilement is in general easily determined; it is not the same thing when those points are sideways, as then the operation becomes often more difficult; for instance, let us suppose that the redan, fig. 132, is commanded by the height A B C which encompasses it, and whose part A B is the most commanding; should this work be placed in a single plane of defilement *a h b*, passing to a requisite height above the most commanding points of A B, without following the inclination of the height from B to C, it would require a considerable relief, which could seldom be allowed to it; if, on the contrary, the plane of defilement should follow that inclination, as the face D of the redan would be lower than the face E,* the assailants placed at C could take in reverse the men on the banquette of the face E, and plunge their fire into part of the work: this method, however, is preferable to the former, when, without obstructing the redan beyond certain limits, a traverse F may be constructed within it; but should its small extent prevent the placing of a traverse, either the other method must be used,

* The reason is obvious, since the plane of defilement, in this case, would be inclined from E to D.

notwithstanding the inconveniencies arising from it, or the construction of the redan given up. I observe by the way, that although the command of the height A B C is not uniform, yet the plane of defilement should be so disposed that the saliant *d* will be the highest part of the work; thus, if we suppose that the point A is more commanding than the point B which faces the saliant, the plane of defilement, which must pass over A, ought to be uniformly conducted towards B, without having any inclination from A to B; nay, the situation of the height, with regard to the work, may require that the plane of defilement should be raised towards B, although the height is inclined from A to B.

The position and height of the traverse F should be determined in the following manner:

After fixing the relief of the work by means of a single plane of defilement inclined from E to D, as has been said, move about a staff 6 feet high along its gorge *a b*, by gradually approaching the face D, till you find a point *c* sufficiently near to that face, that a visual ray tangential to the head of the staff, and to the interior crest of the parapet of the face D, would pass, if produced, 4 feet, or 7 feet 6 inches, No. 193, above the most commanding points of the height C; the line *c d*, drawn from the point *c* to the saliant *d* of the redan, will give the direction of the traverse F (which is also represented in fig. 133). With regard

to its height, it should be determined by visual rays C *e*, fig. 133, elevated 4 feet, or 7 feet 6 inches, No. 193, above the most commanding points of the height C, and 18 or 20 inches above the interior crest of the parapet of the face E.*

By this method, the position of the traverse cannot be regulated at pleasure, as it evidently depends on the elevation of the face D; now, it may happen that the relief of that face will require the traverse to be placed at a point where it would be in the way: if in fig. 132, for instance, the traverse should have the direction *c d*, it would undoubtedly prevent the communication with the bridge *e* which the work covers, and the traverse in this case must indispensably be constructed in another place.

200. When no inconveniency arises from the traverse being placed nearer to the face D, in the direction *f d* for example, it is useless to alter the relief of that face; for, if we suppose it sufficiently high to cover the terreplein at *c*, much more will it be so to cover it at *f*: but should the traverse, on the contrary, be constructed farther from the face D, and have such a direction as *g d*, then the relief of the work must indispensably be aug-

* Should those visual rays pass to less than 18 or 20 inches above the interior crest of the parapet of the face E, the men on the banquette *i* would be seen in reverse from the height C, as they stand so many inches higher than that crest.

mented,* so that the face D may acquire a sufficient height that visual rays, grazing the interior crest of its parapet, and directed to 4 feet or 7 feet 6 inches above the most commanding points of the height C, will pass 6 feet higher than the terreplein along the traverse *g d*.

201. I have hitherto supposed the relief of the work to be regulated by means of a single plane of defilement, and I now observe, that the operation may also be performed with two planes A*f*, C*f*, (pl. 30, fig. 134, and pl. 29, fig. 133,) inclined in contrary directions, and which should meet the traverse 6 feet, at least, higher than the part of the terreplein where it is constructed.† By this method, the relief of the work at its profiles *a* and *b*,

* Unless you place two traverses in the work; in which case, the relief of the face D only should be increased. One of them must be sufficiently near the face D, that the terreplein between it and that face may be covered: with regard to its relief, it should be regulated in the following manner; the summit of the traverse must be placed in a plane directed to 4 feet or 7 feet 6 inches, No. 193, above the most commanding points of the height C, and which cuts the other traverse 6 feet higher than the terreplein.

† This method should particularly be preferred, when the elevation of the heights that encompass the work is very irregular, and when their inclination, in one way or the other, is not uniform or nearly so. After all, an engineer who is to defile a work, must be guided by his own experience, in determining upon the method which, according to localities, will be the most convenient and expeditious.

cannot be fixed at pleasure, as it is in some degree in the other method, since it depends on the position of the traverse *c d*, by which the requisite inclination of the two planes of defilement is determined; therefore, you ought to fix, first, the situation of the traverse according to localities, and then combine the inclination of those planes in such a manner that they will pass 4 feet, or 7 feet 6 inches, above the most commanding points of the heights A and C, and meet the traverse 6 feet, at least, higher than the part of the terreplein which it occupies, as has been explained.* With regard to the relief of the traverse, it should be determined as in the preceding example, No. 199.

202. When two planes of defilement are used, in order to determine the relief of a work, it most commonly happens, that, as those planes have not the same inclination, one of the faces is lower than the other, so that the interior crests of their para-

* Should you first determine the inclination of the two planes of defilement, with an intention of placing the traverse afterwards, at their intersection, it would frequently happen, that after taking much trouble in combining the requisite inclination of those planes, so that they may meet 6 feet, at least, higher than the terreplein of the work, localities would not allow you to place the traverse at their intersection; wherefore you would have to give them a *different inclination*, which, *perhaps, would* not answer better than the first; but if you begin with fixing the *situation of the* traverse, as I have recommended, this inconveniency will be removed.

pets cannot meet at the saliant, unless you should increase the relief of the lowest face; but this is useless, as it would augment the labour without procuring any advantages for the defence, since the inconveniences arising from the unequal elevation of the faces at the saliant will be removed by the height of the traverse.

203. In order to explain, with greater perspicuity, the methods which I have hitherto recommended with regard to defilement, I have applied them to works composed of a small number of sides, and whose figures are nearly regular: indeed, the process to be followed in defiling those of which the irregularity and number of sides are greater, is founded on the same principles, but the operation becomes longer and more complicated as the irregularity of the works and their number of sides increase; and particularly as the heights which command them stand in their front, or sideways; for instance, let us suppose that a work X, fig. 135, should be defiled from the height A which commands it in front: in this case, the operation will not differ from those explained in No. 195 and 198; that is, the work shall be placed in a single plane of defilement passing 4 feet, or 7 feet and a half, above the most commanding point of the height A, and through the heads of the staves *e a* and *d c*, which fix the relief of the sides *e f* and *d g* at their extremities *e* and *d*; but should a

work be encompassed by commanding heights, several planes of defilement will be requisite, and a number of traverses so much the greater, as the points from which the assailants may take the garrison in reverse will be the more numerous. I shall not expatiate any longer on this subject, as it is impossible to foresee all cases, and to point out a particular method for every circumstance; besides, what I have said will suffice to guide an engineer in most cases.

204. Should an isolated work, whose gorge is open and protected by troops behind it, be commanded by heights from a less distance than the reach of the arms with which it may be attacked, defilement will not rectify the defects arising from its bad situation; for, only its garrison can be secured by that means, and the troops in its rear will be exposed and forced to retreat, without being able to defend it. Nay, defilement will not answer a more useful purpose, in a work whose gorge is supported by an obstacle that prevents it from being turned, but which is intended to cover and protect a bridge of communication, a dam, &c. which the assailants can see and destroy from the heights; for, what advantage could you derive from the garrison of the work being secured, should not the object for which it is constructed be attained? I now proceed to the defilement of enclosed works.

205. Defilement is less applicable to enclosed

should be placed in a particular plane of defilement, and that a traverse *e f* should be constructed which the two planes must meet, conformably to what has been explained in No. 201. Now, as the side *b c* ought also to be covered from the reverse fire which may come from the ground D behind, (unless the redoubt be situated on an eminence, No. 205, note,) another traverse *g h* is requisite, crossing the former; whence it follows that a work which is so commanded can scarcely be defiled; for, not only the disposition of the planes of defilement, and the construction of the traverses require much time, and give rise to many difficulties, but the latter obstruct the interior of the work which, therefore, cannot be so well defended.*

When you intend to construct a guard-house, within a work where a traverse must be placed as a security from the fire of musketry, it should be so disposed as to form the traverse, which will diminish the labour, and the obstruction inside of the work. Nay, should a work, which is only intended to resist musketry, be situated in a plain,

* It would be still worse, should the redoubt be surrounded by the heights which command it; for, in this case, the interior crest of its parapet should be placed in a plane of defilement passing above the most commanding points of those heights, which cannot be done; therefore, we may conclude, that a position of this sort should not be fortified.

and a guard-house be required, the latter ought to face the spot on which the attack is likely to be made; but as a guard-house cannot answer the purpose of a traverse, when a work may be attacked with cannon, it must be constructed in this case with timber inside of the traverse, as it will be more secure, and will less obstruct the manœuvres which the defence of the work may require.

207. It remains to explain the method of defiling field-works which form a continued line: and I shall first observe, that as those works are always thrown up for some important purpose, the assailants will undoubtedly use their cannon in attacking them; therefore, they must be defiled, when the distance of the heights which command them is not greater than from 500 to 600 toises.

I shall observe, likewise, that an engineer who is to construct field-works, is less confined in his choice of the spot, than when he is to erect a fortress;* therefore, he should not place a continued line at the foot of heights which require that it should be defiled, and particularly when it is encompassed by them; for, of what import is it that the works should be secure, if the troops encamped behind them for their defence, and which they

* When a fortress is to be raised, its situation is generally determined by the nature of the frontier where it is erected, and by political considerations.

must cover, are exposed from the heights, and cannot remain in their camp? When such positions occur, the heights should be occupied and fortified.

208. But it may happen, that by the nature of the position which you intend to occupy, the line is to cross either at a valley of small extent, and where troops cannot be encamped, or a considerable valley in which a camp must be established; it may happen, too, that the line is only to cross part of a valley: I shall successively examine those different cases.

Let us first suppose, that the line should cross the valley A B, pl. 31, fig. 138, whose breadth is only from 100 to 150 toises: construct across the latter a double redan, as is shewn by the figure, and make the branches *c* and *d*, which are placed on the heights, sufficiently saliant, that the prolongations of the faces of the double redan may meet them; in this manner you will be secured from the reverse fire of the assailants posted on the summits *e* and *f* of the heights, or on their declivities; next, place the parapets of the faces of the double redan in two planes of defilement properly elevated above the most commanding points of the heights *e* and *f*, and meeting each other along the capital of the redan *g* which occupies the bottom of the valley.

Or else; make use of the tracing with bastions,

and determine, first, whether a bastion or a curtain shall be placed in the bottom of the valley. Let it be a bastion, as in fig. 139. In this case, trace it in such a manner that the prolongations of its faces will meet the collateral bastions *a* and *b* on the heights, and for the same reason as I have explained with regard to the faces of the double redan fig. 138; next construct a traverse *c* along its capital, where two planes of defilement, directed as in the preceding example, shall meet.

But, should a curtain be placed in the bottom of the valley, fig. 140, break it inwards, No. 42,* as it will be more secure. Next, trace the flanks *a b* and *c d* perpendicular to the lines of defence *e a* and *f c;* lastly, regulate, the relief by means of two planes of defilement, as before, which being produced towards the bottom of

* Should the curtain form a straight line, as *a c*, an immense remblai would be requisite towards its centre. The angle *a i c*, which the brisure of the curtain makes, must be obtuse; for, should it be acute, or right, the fire of the sides *a g* and *c h* would be directed against the opposite flanks *c d* and *a b*.

I here observe, that a curtain should not be placed in the bottom of a valley, unless the breadth of the latter be no more than 60 toises, at most; for, the flanks ought to be placed on the crests of the heights, in order that their fire may be more effective, and their banquettes secured from the reverse and enfilading fire of the assailants; and their distance from the opposite flanked angle would be too great, if the breadth of the valley exceeded 60 toises.

the valley, will follow, as much as the requisite command of every part of the fortification may allow it, a direction parallel to the slopes of the heights. The points where those planes cut the staves placed at *g h*, will determine the relief of the line *g h*.

209. When a line crosses a valley C D, fig. 141, larger than the preceding, but which is not sufficiently broad to allow a camp to be formed within it, the works across the valley must be re-entering with regard to those *d*, *e*, upon the heights, A, B, so that the prolongation of the faces of the former would meet the latter; and their parapets should be placed in two planes of defilement meeting each other along the capital of the redan *b*.

210. Now if it be supposed that the valley C D is sufficiently large to allow troops to encamp within it, not only the part of the intrenchments which crosses the valley must be re-entering with regard to those *d* and *e* upon the heights, but works should be constructed in front of the latter, and they should be so disposed as to prevent the assailants from establishing themselves (either on the heights or on their declivities) nearer than 600 toises from the extremities of the re-entering part of the line; for, could they approach within that distance, they would destroy the camp with their cannon.

211. Lastly, should the intrenchments cross only

part of the valley C D, and then take a direction parallel, or nearly so, to the height B, you ought to ascertain whether this height is less distant than 600 toises from the intrenchments which face it; in which case, it must be occupied by works so disposed as to prevent the enemy from approaching nearer than 600 toises from the extremities of those intrenchments.

212. I have endeavoured to explain with perspicuity, the most convenient methods of defiling field-works in general, and it does not occur to me that I have omitted any thing which may enable the reader to comprehend easily how that ingenious contrivance may be applied; I advise him, however, to consider it only as palliating the defects which arise from a bad position; first, because the small relief, which field-works generally have, scarcely suffices to cover the defenders of those which are not commanded; secondly, because the preparatory means which precede the defilement of permanent works, and render it less uncertain, can rarely be used in the field, where an engineer is most frequently confined, as I have said before, to practical methods, which require from him a great deal of care, attention and *coup d'œil*, without being always attended with success; sometimes after taking much pains, and wasting away considerable time in defiling a work, he per-

ceives defects which oblige him to begin his operation again, and as unsuccessfully as before. The interior of the work may be covered, but the soldiers on the banquettes are nearly, or quite as much exposed; therefore, your chief attention must be directed to the disposition of the works, and especially to their situation; and too much reliance on the good effect of defilement ought not to induce you to occupy a position which is commanded, unless you cannot avoid it, in which case defilement, and particularly traverses, may undoubtedly answer a very useful purpose. No particular rule can be given respecting the proper situation of the latter, as it depends on the points from which the assailants may see the troops in reverse. With regard to their thickness at top, it should be regulated by the importance of the work, the nature of the attack which it is intended to resist, and by the proximity of the points whence the enemy can batter it in reverse, should he use his cannon. When the work is only exposed to the fire of musketry, or the enemy is unable to place guns at the points from which he could fire into it, a thickness of 12 or 18 inches will suffice., but should an attack with cannon be expected, from 4 to 10 feet are requisite, according to the nature of the guns which the assailants may bring, and to the near-

ness of the points where they can dispose them advantageously.*

213. The slopes of the traverses should be as little inclined as the nature of the soil will allow, in order not to obstruct, without necessity, the interior of the work. It is proper, likewise, that they should have a banquette, and particularly when they are placed opposite to the ground where the attack is likely to be made; wherefore, their tops must, of course, be made sloping, in the form of a parapet.†

214. When a traverse extends all across the work, fig. 142 and 143, a communication should be made from the part *a* to the other part *b*, either by means of one or several passages *c*, *d*, cut through the traverse, and supported by timber-work, as in fig. 142, or by forming the traverse of several masses *e*, *f*, fig. 143, crossing over each other, so as to cover the passage *g* between them.

* A traverse does not require the same thickness as the parapet of the work, as it is not exposed to an attack purposely directed against it. The assailants see it only from a distance, and prefer ruining the parapet, which is more important to them.

† A banquette is particularly useful when the traverse crosses the whole work, as it answers the purpose of a redoubt.

END OF THE SECOND PART.

PART THE THIRD.

CHAPTER VI.

Further Considerations on INTRENCHMENTS OF ARMIES; *of* LINES OF FRONTIERS; *of* POSTS OF FRONTIERS; *and other* POSTS; *of* INTRENCHED CAMPS OF FRONTIERS; *of* GRAND TETES DE PONT.

215. IT has been said, in No. 49, that the whole of the works and obstacles by which an army, or a considerable body of troops cover themselves, for their own defence, are called intrenchments of armies; and that they are generally intended to interpose between the army and the enemy a defensive line, which may compensate for the inferiority in number of the former; the reasons why those intrenchments are most frequently irregular have also been explained in No. 50: and now I observe, that the particular views of the army require likewise differences in the manner of dis-

posing and constructing the intrenchments which it throws up.

Let us suppose, for instance, that the army is to remain in a position which it proposes to take; either to observe the movements of the enemy, or because the position itself must be guarded and defended; in those two cases, it is the spot, where the army is encamped, which is to be fortified; and as positions of this kind are in general settled upon a long while before they are occupied, you have time to construct intrenchments capable of a great resistance, which the enemy cannot attack and carry without using means which he does not commonly possess; but if an army is forced to a battle by superior forces, and obliged to prepare immediately for it, or should it retreat in the presence of the enemy, as it has no time to throw up intrenchments which may fully compensate for its inferiority in number, it is compelled to cover itself in haste by a few works, whose proper disposition and situation should make up for their small number and imperfect construction.

216. The following general principles should be observed, as much as possible in the formation of intrenchments of armies.

1. Their flanks must be supported, and not exposed to be turned; for, of what avail would be the defence in front which intrenchments afford, could they be attacked in the rear?

2. Their extent should be proportionate to the strength of the army which they cover, since they are to be defended by it.

3. In tracing those intrenchments, you ought to avail yourself of every natural accident of the ground which they traverse; a low and marshy spot, a stream whose banks may be overflowed, a ravine, a wood where an abatis may be formed, and other natural obstacles, frequently afford great advantages, when properly connected with the other defences; either by increasing the strength of some parts of the line, or, when they suffice to stop the assailants, by saving you the time and labour, which, without them, the construction of works would require.

4. The line formed by intrenchments of armies should occupy, as much as possible, the elevated parts of the ground which it crosses, and border the summits of the heights or hills in its direction; by which means, the intrenchments will have a superiority over the assailants who cannot approach them without passing through uneven and difficult ground.

5. Every point of the ground in front of an intrenchment, must be seen and defended by some of its parts.

6. The habitations in front of the line should be occupied and fortified, when they are sufficiently

near to be supported by it;* but should they be too distant, and so situated as to conceal the movements of the enemy, they must be destroyed.

7. For the same reason, a wood, which the line can support, must be occupied; but should its distance prevent it, and its situation be such as to conceal the movements of the assailants, it requires to be cut down.

8. The line ought to cover all the habitations in its direction, so as to make them serve as points of support, and to reap advantage from their reverse fire.

9. The number and strength of the respective works depend on the greater or less danger to which the part of the line where they stand may be exposed; if, for instance, the enemy could scarcely approach it, and should he not be able to bring his cannon against it, the works thrown up for its defence would undoubtedly not require the same extent and strength as they would, in case the assailants could easily approach and batter it.

10. All obstacles which may obstruct the communications of the line with such parts in its front as must be protected by it; or which may impede the retreat of the army, should the intrenchments be carried, must be removed.

* The defences thrown up for that purpose, must be so disposed as not to afford a cover to the enemy, should he make himself master of them.

217. Intrenchments with intervals (No. 49,) are now preferred to those which form a continued line. The following are the reasons which are assigned for it; first, the former require less troops for their defence than the latter; so that with an equal number of men, a greater force can be placed at the most exposed points, or stronger reserves be kept; secondly, the intrenched army can form in such order as will not impede its movements; wherefore it will be able to pass successively from the defensive to the offensive, and *vice versa*, according as circumstances may require: whereas, on the contrary, an army placed behind continued intrenchments, must be deployed; and as it can scarcely execute any movements outside of them, it is reduced to defend passively, if I may use that expression, the works which cover it, and are sometimes very imperfect. Thirdly, a line with intervals requires less labour than a continued line; therefore, the works which compose it, can be constructed with greater care in the same time, and with the same number of workmen. Lastly, the former line is more easily adapted to the ground than the latter; as the engineer, who is not confined to a fixed tracing whose parts must all be connected, can place the works at the most essential points of defence.

OF LINES OF FRONTIERS.

218. The works and obstacles disposed along some open parts of a frontier, to shut up the country from one place, or post, to another, are called *lines of frontiers.*

These lines may answer very useful purposes; first, they protect the army which defends the country behind them, and also secure its movements; secondly, they prevent the incursions of the enemy's parties, and the devastation which they would occasion; thirdly, they remove the fears of the inhabitants, who then attend to agriculture. Lastly, they connect the defences of the frontier, and therefore increase the resistance which can be made. Indeed, a line of frontiers will not afford those advantages, unless it be considered in its proper light and used accordingly; for should the army consider it, as forming its own intrenchments, and actually defend it, as lines of frontiers have in general a greater extent than is proportionate to the strength of the army, it follows that the troops would be weak every where; and that they would undoubtedly be crushed by the columns which the enemy would march to several points at once; thus the line would be disadvantageous rather than useful; but on the contrary, should the army support it only with a limited

number of troops, and occupy a position behind, from which it could repair rapidly to all points, and take in flank the enemy's columns when they begin to advance, no doubt can be entertained, in this case, of the utility of the line, and particularly when its extent is not so great as to preclude the army from the possibility of supporting all its parts; for the enemy will be compelled to form partial attacks, and therefore to weaken himself by dividing his forces. The following are the general rules to be attended to, in the construction of lines of frontiers.

219. 1. They require, like intrenchments of armies, that their extremities should be supported, and not exposed to be turned.*

2. Their front ought not to present any unprotected openings, by means of which the enemy may penetrate into the country which they are intended to cover.†

3. When you are to construct a line of frontiers, you should avail yourself of all the obstacles which the ground that it traverses may offer.

4. That the line may have points of support, the open towns and villages inclosed by it should be

* Should a line of frontiers be very extensive, it must be directed from one fortress to another, when there are any on the frontier.

† The reason is evident, since a line of frontiers is chiefly intended to shut up the country which it covers.

fortified; this is particularly requisite, when they occupy important points, and when, by their situation, they can see in reverse some other parts of the line.

5. As all the points of a line of frontiers are not equally accessible to the enemy, the obstacles which form it do not all require the same degree of resistance; for instance, should some parts of the line traverse an open country, through which the enemy might easily penetrate, whilst others pass over a marshy or woody ground, &c. which scarcely allows him to approach, the former would undoubtedly require stronger defences than the latter.

6. Since a line of frontiers is chiefly intended to secure the country behind it from the enemy's parties,* the works which it contains do not require a greater relief than that which field-works commonly have; not even in its most accessible points; and according to circumstances, from three to eight feet at most will suffice for the thickness of their parapets.†

7. Great advantages may be derived from

* Those parties have frequently no guns; and when they have, they are in general small.

† It is scarcely necessary to observe, that the former dimension is applicable to such works as are only to be secured from the fire of musketry; and the latter, to those which may be attacked with cannon.

streams, and particularly when they are broad and deep, and have steep banks; or when the ground on their banks is marshy; should they contain islands, those on the side of the army must be occupied, in order to prevent the enemy from throwing up defences within them, under the protection of which he could more easily pass the stream; with regard to those on the other side, they ought to be observed by posts which are ordered to retreat when the enemy appears with a superior force;* all thickets, brush-wood, &c. which might favour and conceal his movements, should be cut down.

8. All fords must be guarded by strong posts, and no bridges suffered to remain, except those which are indispensably necessary to penetrate into the enemy's country, should circumstances require it; when they are not situated within a fortress, or protected by it, the place where they stand should be more or less strongly fortified, according to the importance of the passage, and to the greater or less facility which the enemy may have of approaching them.

9. A small stream may also be rendered serviceable, by means of dams thrown across its bed; so

* It is less important to occupy those islands than the others; besides, should they be attacked, you could not keep them on account of the impossibility of conveying a sufficient force to defend them.

as to form small inundations which render the access to the low parts of the ground more difficult to the enemy. The sluices of the water-mills, manufactories, &c. which are commonly found on the banks of such streams, may be used likewise to that purpose, and those buildings should be fortified. Morasses too, and even marshes, are a very good barrier, as the enemy cannot attempt to pass them without danger, and particularly with his cannon; therefore, when the disposition and direction of the line allow some parts of it to be protected by such obstacles, you ought to avail yourself of them.

10. A few redoubts placed near the most accessible points of a ravine, and on those whence a reverse fire can be most easily obtained, will suffice to defend such passages.

11. The woods which are in the direction of the line, may also procure advantages by means of abatis made within them, and supported by a few detached works. The ground in front of the abatis should be cleared to a certain distance, in order that the enemy may not conceal his movements and approach unperceived.

12. Should a mountain be in the direction of the line, its passages must be guarded by posts sufficiently strong to secure them.

13. Wherever the country is open, and unprotected by natural obstacles, works ought to be

thrown up, whose requisite strength depends on the importance of the points which they cover, the facility which the enemy may have of approaching them, and on the advantages which the ground affords for his manœuvres.

OF POSTS OF FRONTIERS AND OTHER POSTS.

220. *Posts of frontiers* are intended to secure, with a limited number of troops, the principal points of a frontier which is not defended by an army, nor by fortresses, the number, situation, and extent of which, are properly adapted to localities;* for, should it be protected by such fortresses, their garrisons would suffice to guard it.

221. In a mountainous country, the vallies are chiefly inhabited, as they are more fertile and better supplied with water, communications and accommodations of all sorts, than the elevated parts; wherefore the towns,† or villages situated within

* It happens frequently that a frontier is actually defended by fortresses, but that they are not properly adapted to localities; in which case, intermediate points must be occupied by posts, so as to rectify the defects in the defence.

† When posts are to be disposed along a frontier, the principal of them should be placed in the towns; as, in general, they are situated near the most convenient communications, and in the most fertile parts of the country. Besides, they afford greater resources of every description, than any other place.

them, or near their openings, and in the plains contiguous to them, are particularly suitable to the establishment of posts; those which defend the principal gorges, and serve as places of *rendezvous* and depots, should be strongly fortified, and preceded by smaller posts, in order to watch the enemy's movements; with regard to the other gorges, they should be guarded by posts whose requisite strength depends on the facility which they may give to the enemy, to penetrate into the country.

222. Flat and open countries are more difficult to guard than the preceding; in such countries, the chief towns should be occupied, and those placed on the communications be more or less strongly fortified, according to the importance of the points where they are situated;* intrenched camps, of which I shall speak hereafter, may also be formed, where their position enables them to be of service for the general defence of the frontier.

223. No particular rule can be given, with regard to the method of fortifying posts of frontiers, since it depends on the configuration of the ground, the time which you can command, &c. But I observe, that as those posts are intended to

* It is particularly requisite that those towns should be capable of a strong resistance, when they are situated in fertile plains, as armies attempt generally to advance through the most fruitful parts of a country.

serve instead of fortresses, particular attention must be paid to the dispositions for their defence; and that you should avail yourself of every advantage which localities may offer; a stream which allows an inundation to be formed, or whose passage may be rendered difficult to the enemy by other convenient means; an impassable morass which secures part of the post, or a marshy ground which obstructs the approach to it; a wood where an abatis, properly supported, can be made; or which must be entirely cut down, as it would conceal the enemy's movements, and expose the post to be surprised; buildings, which, being placed between two works, form a sort of curtain connecting their defences, and whose walls may be pierced with loop-holes; or which project in front of the post, and will flank part of it, after being secured by works, or by other practicable dispositions: some other buildings, which must be pulled down, either because they would mask the fire of the post and render it less effective, or because they would favour the enemy's approach, and enable him to see into the post: a street, which should be barricaded, or cut across by trenches: some particular points, where works must be thrown up, as, on account of their situations, their fire will flank other works, or defend them in reverse: a ravine, a ditch, a steep ground, &c. which may strengthen the defence, or which would weaken it, should

not proper precautions be taken: these, and other considerations, which circumstances may require, should fix the attention of an engineer, in forming his plan for the defence of a post, and if he cannot depend upon sufficient time to complete all the dispositions which are requisite, he must attend, first, to the most essential;* next, to those which are less important; and ultimately to the formation of such works and obstacles, as will improve the defence of the post, although it may not indispensably require them.

224. Now, let us suppose that an army intends to invade the territory of the enemy, and to remain therein; in this case, the march of the army requires particular precautions suitable to the nature of the frontier through which it proposes to penetrate: for instance, should the frontier be protected by fortresses well calculated in all respects for its defence, they must be taken as the army advances, and then be repaired, garrisoned, and supplied with stores and provisions, in order to keep in awe the invaded country, and afford points of support which may secure the army's retreat, should it be compelled to fall back, and

* The first step to be taken in such case, is to secure the post from a coup de main. It is scarcely necessary to observe, that the defences thrown up for that purpose, must be so disposed as not to prevent the addition of others, should circumstances permit it.

supply all its wants; but if the country is open, and destitute of fortresses, posts strongly fortified must be established near the principal communications, and in the points most advantageously situated to defend it, and secure the army's retreat, if necessary; indeed, less precautions are requisite, when the army which invades such a country intends only to make a temporary stand, either to levy contributions, or to draw in the enemy and make a diversion; however, it should occupy, as it advances, the principal communications, and the positions which will secure its flanks and rear; as, otherwise, its subsistences would be continually exposed to be burnt or taken away by the parties of the enemy; besides, the rear of the army would be annoyed, and the army, perhaps, be cut off.

225. The winter-quarters of an army, and particularly in a hostile country, should also be covered by posts so placed as to defend the principal communications; for without it the quarters will not be secure, nor will the troops enjoy any repose, as they may be attacked at every moment: nay, should the enemy take the field early, and attack the quarters before they have time to assemble, he might crush them, and thus destroy part of the army in the beginning of the campaign.

As all posts should be fortified according to the same general principles, I refer the reader to the

hints which I have given in No. 223, when speaking of posts of frontiers.

OF INTRENCHED CAMPS OF FRONTIERS.

226. Some of the positions to be occupied along a frontier, for its defence, may not be inhabited, or the number of habitations which they contain may be too small for the troops, which in those two cases must be encamped; and then the positions take the name of *intrenched camps of frontiers*.

227. There are two sorts of intrenched camps of frontiers; namely, those which have a small extent, and are only intended to guard the points where they are placed; they differ from posts of frontiers, of which I have been speaking in the preceding section, merely because they are situated in an uninhabited place; and what I have explained, with regard to the former, is also applicable to the latter, with some modifications which the difference in their situation may require. The other intrenched camps of frontiers contain a considerable body of troops, and are intended not only to guard the points where they are established, but to cover the country: these camps, which are formed for the same purpose as flying camps, and only differ from them as they are fortified, afford great advantages, when properly disposed; they

keep the enemy in check, and prevent him from penetrating through some weak points of the frontier, in order to advance in the country; for then his flanks and rear would be exposed to be attacked by the encamped troops, as they can march in all directions; his lines of communication would not be safe, and his retreat might be cut off. It is evident that camps of this sort require to be so fortified as to afford a resistance proportionate to their object, and to the importance of the points which they occupy; and that their situations must be such as not to expose them to be rapidly and unexpectedly surrounded; for the troops could not march to the threatened points, nor make good their retreat when their safety required it; and therefore they would be exposed to no purpose.

The proper situation for an intrenched camp of frontiers requires, likewise, that it cannot be taken in reverse, nor the troops prevented from retreating or communicating with other parts of the frontier, according to circumstances; and that the enemy may not, by crushing some posts, oblige the encamped troops to withdraw from their intrenched position, for fear of their retreat being cut off. Lastly, it should be examined, whether the situation of the camp affords easy means to penetrate into the enemy's country, should such offensive movement be requisite, and whether it can be placed in a spot protected by some natural

obstacles, as then it will require less time and labour in fortifying.

OF GRAND TETES DE PONT.

228. When part of a frontier is covered by a river, it is necessary to secure the principal communications across it, so that an army may march to the enemy's country, or retreat from it, according to circumstances: *grand têtes de pont* are constructed for that purpose.

229. It is evident that grand têtes de pont ought to be capable of a great resistance; for, as their object is very important, the enemy has a material interest in destroying them; they require also a rather considerable extent, in order to contain a sufficient number of troops to check him, when the army is advancing or retreating through them. Lastly, they must be so disposed as to prevent him from perceiving the bridges which they encompass; otherwise he would attempt to destroy them, from a distance, with his cannon.

230. When the communication to be secured is situated in a town, and not seen from without, the part of the town beyond the river must be fortified, and then it serves as a tête de pont.

231. But should the opening of the communication be outside of the town, and seen from the

country, not only the town must be fortified, but the opening requires to be covered by works sufficiently extensive to hide the bridges; or the points from which the enemy can see and batter them must be fortified.

232. Lastly, if the communication is at a certain distance from the town, its opening towards the enemy should be fortified, and the requisite precautions taken to secure the bridges from being battered.

It happens frequently that these grand communications across rivers are only established in time of war; wherefore, the bridges which form them have no great solidity: in this case, stoccados should be constructed in the upper part of the river, so as to stop every thing which the enemy may let go with the current, to break open or destroy the bridges.

233. When there are islands near a tête de pont, those whence the enemy could take it in reverse or batter the bridges, should be fortified.

I have confined myself to the general rules, which I have explained, respecting grand têtes de pont; as the particulars relative to their construction must be determined by the nature of the ground where they are placed, and by the degree of importance of the communication which they protect.

THE END.

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